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FARMERS' BULLETINS
Nos. 1326-1350

WITH CONTENTS

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U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1326

CONTROL OF THE CODLING MOTH IN THE PACIFIC NORTHWEST

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THE CODLING MOTH is at present the most serious insect pest with which the apple and pear growers of the Pacific Northwest have to contend. Losses from "worms" in some years average as high as 20 per cent of the total crop, and losses sustained by individual growers are often more than 50 per cent of their crops. On the other hand, by using proper methods, many growers keep their losses well below 5 per cent. A knowledge of the habits of the insect is essential for the intelligent application of control methods.

This bulletin briefly describes the various stages of the codling moth and gives an account of its habits. A pictorial diagram of the life cycle is given in Figure 6. Detailed spraying instructions are set forth and other control methods are suggested. Combined spray schedules will be found at the end of this bulletin, showing how the apple powdery mildew and scab sprays may be combined with the codling moth sprays.

Washington, D. C. March, 1924

CONTROL OF THE CODLING MOTH IN THE PACIFIC NORTHWEST.

By E. J. Newcomer and M. A. Yothers, *Entomologists*, and W. D. Whitcomb, *Assistant Entomologist, Fruit Insect Investigations, Bureau of Entomology*.

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LOSSES DUE TO THE CODLING MOTH.

THE CODLING MOTH[1] is the most serious insect enemy of apples and pears in the Pacific Northwest, taking the region as a whole. Estimated losses from this insect alone run as high as 20 per cent of the total crop of the region in some years. This loss is in spite of the fact that practically all of the growers spray their trees with arsenate of lead from one to six times every season. It is obvious that there is need of improvement, both in the timing of the sprays and in the methods of application. Many growers are consistently keeping their losses from this insect below 5 per cent annually, and others can do as well by following the proper methods.

NATURE OF INJURY.

The larva or "worm" is the only stage of the codling moth which is injurious, and the only injury of consequence is to the fruit. The young worms, upon hatching from the eggs, seek out the nearest fruit and burrow into it, producing the familiar wormy apple or pear (see title page). A fruit in this condition, though not totally ruined, loses most of its commercial value, since it will not keep long, and the laws of some States forbid its being shipped, except to by-products plants. The value of such fruit, on the average, is not more than one-eighth of the value of sound fruit. It therefore pays to produce sound apples and pears.

DISTRIBUTION AND FOOD PLANTS.

The codling moth is found in practically all localities where apples or pears are grown. No place where these fruits can be raised may be said to be immune, though some sections, particularly the newer ones, are not yet troubled with it. It will get a foothold in these places also, in course of time, unless stringent measures are taken to keep it out. Isolated orchards are perhaps the safest from attack, if care is taken not to introduce worms in fruit or boxes, or in other ways. The codling moth does not spread rapidly by itself.

---

[1] *Carpocapsa pomonella* L.

In the cooler regions the worms will probably never be as serious as in warmer regions. This is because the shorter season causes more of the first brood of worms to delay transforming to moths until the following year, resulting in a smaller second brood.

The apple is the preferred food of the codling moth, and by far the greatest injury is suffered by this fruit. Some varieties are more susceptible than others. The Winesap and Arkansas Black are attacked less, while some of the more fragrant varieties, such as the Spitzenberg and the Delicious, are preferred. Summer varieties, which ripen while the worms are still active, are always more wormy than the late varieties. Crab apples are infested somewhat.

Pears are also attacked by the codling moth to a great extent, early varieties, such as the Bartlett, being favored. Pears are hardier than apples, and where the two are grown together the insect much prefers the apples. Pears grown in considerable acreages by themselves, however, often become nearly as badly infested as apples.

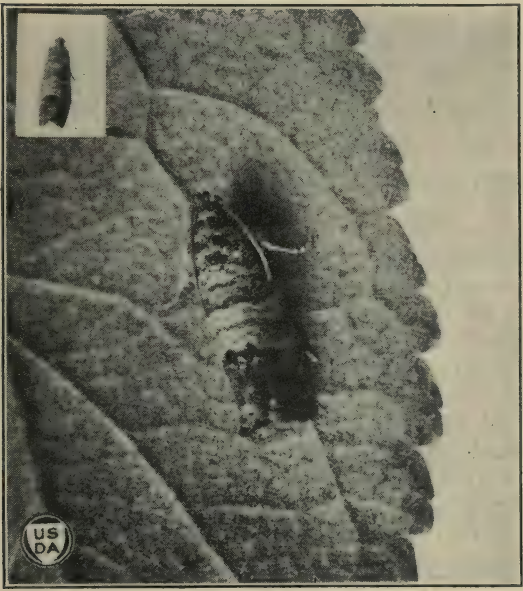

Fig. 1.—Codling moth, enlarged; inset, natural size.

In addition to apples and pears, the codling moth has been recorded as infesting peaches, cherries, plums, prunes, quinces, and apricots. These infestations are of little consequence, usually occurring where such varieties are interplanted with badly infested apples. In recent years, walnuts have become infested in some parts of California, but in the Northwest the limited plantings of walnuts have not yet shown signs of injury.

APPEARANCE AND HABITS OF THE CODLING MOTH.

Successful control of the codling moth requires an ability to recognize the insect in its different stages.

THE MOTH.

The adult insect, which is seldom observed by the orchardist, is a small, inconspicuous moth (fig. 1). The female is usually a little larger than the male, and has a maximum wing spread of about three-fourths of an inch. The front or upper wings are brownish gray, crossed with lines of lighter gray, and have a bronze band at the tip. The hind wings, which are covered when the moth is at rest, are grayish brown. The average length of life of the moths is two weeks.

The moths feed very little and begin to lay eggs in one or two days after they appear, if the weather is favorable. The greatest activity occurs at dusk. Most of the eggs are deposited at this time, and only when the temperature is above 60° F. The number of eggs laid by each female varies greatly, but under favorable conditions the average is about 40. The eggs are deposited singly, those laid in the early summer being placed mostly on the leaves and twigs, while later many of the eggs are found on the fruit.

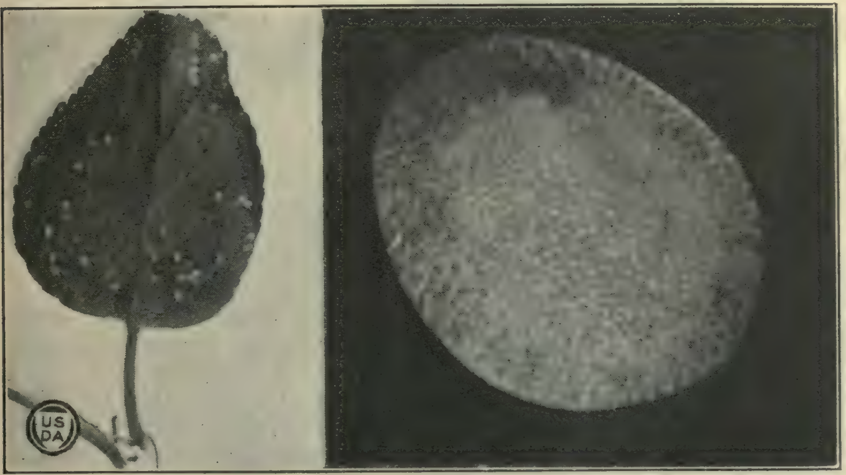

FIG. 2.—Codling-moth eggs: Left, natural size, on apple leaf; right, single egg, much enlarged.

Codling moths are capable of flying half a mile or more. In orchard sections, however, they do not ordinarily travel far, unless carried by the wind, as their object is to reach a tree on which to deposit eggs.

THE EGG.

The pearly white egg is about the size of a pinhead and resembles a thin convex disk (fig. 2.) A few days after the egg is laid, a red ring, the germ band, becomes apparent, and the day before the worm hatches, a black spot, the head of the worm, is easily seen. The eggs are extremely sensitive to temperature. High temperatures will hatch the worms in 5 days, and cool weather has retarded the incubation for as long as 23 days. The average incubation period is about 10 days.

THE LARVA OR WORM.

It is the larva or worm of the codling moth that feeds on the fruit, and in this stage it is most susceptible to control measures. All fruit growers are familiar with the pink or white worm, about five-eighths of an inch long, which is the full-grown larva of the codling moth (fig. 3). Immediately after hatching from the egg, the young worm, scarcely one-eighth of an inch long, with a black head appearing too large for its slender body, begins a very active search for food. It never enters the fruit beneath the shell of the egg, but emerges from a hole broken in the upper side of the eggshell near the edge. It then crawls rapidly about, until a suitable place of entrance into the fruit is found. The calyx cup, the stem cavity, or an injury to the skin of the fruit is preferred, as it affords protection and an easy entrance. Many worms of the summer broods burrow directly into the side of the fruit. In about 1½ hours the worm has eaten through the skin, excavated a cell just beneath the surface, and covered the entrance hole with frass which is held together with silken threads.

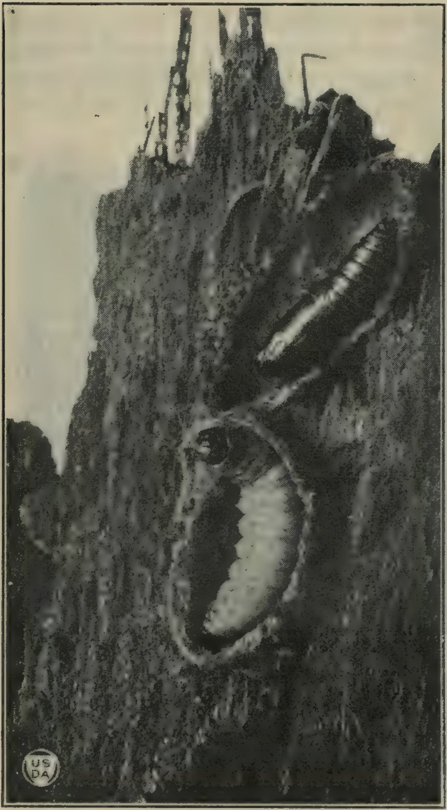

FIG. 3.—Larva and pupa of codling moth, in cocoons. Twice natural size.

For a few days the worm feeds near the surface, or in the outer cavity of the calyx, before burrowing to the center of the fruit, where it remains, often feeding on the seeds, until it is full grown. When of full size it makes an exit tunnel to the surface, from which it soon leaves the fruit and seeks a place to spin its cocoon. The exit hole is ordinarily more evenly rounded and larger than the entrance hole.

If the young worm dies from the effects of poison, is killed by predacious enemies, or leaves the entrance hole for any reason before it has burrowed more than one-eighth of an inch from the surface of the fruit, the resulting injury is called a "sting" (fig. 4). Because of the hard flesh and smooth skin of pears, worms attacking this fruit enter at the calyx or at the stem end more often than in apples. When a worm enters the side of a pear, the characteristic surface feeding is usually absent and the small entrance hole has the appearance of an unhealed sting. Occasionally larvæ are seen burrowing into the veins of leaves and the terminal shoots of twigs, but they seem unable to develop to maturity on food of this kind.

THE COCOON.

The tough, waterproof cocoon (fig. 3) is woven of white silken threads with which bits of bark, wood, and leaves are often mixed. Cocoons are spun in any protected place, and are more commonly found about the tree under rough pieces of bark and in cracks or wounds in the branches and trunk. They also occur about the packing sheds, in cracks in the floor and walls, and in corners of boxes and barrels. Many worms spin their cocoons in the ground near the trunk of the tree.

THE PUPA.

While undergoing the changes from worm to moth, the insect is called a pupa (fig. 3). At first this is amber colored, changing later to a dark brown. When the necessary changes have taken place, the pupa wriggles its way out of the cocoon, the pupal case splits at the front, and the moth emerges. The empty pupal cases are frequently seen in the orchard protruding from cocoons (fig. 5).

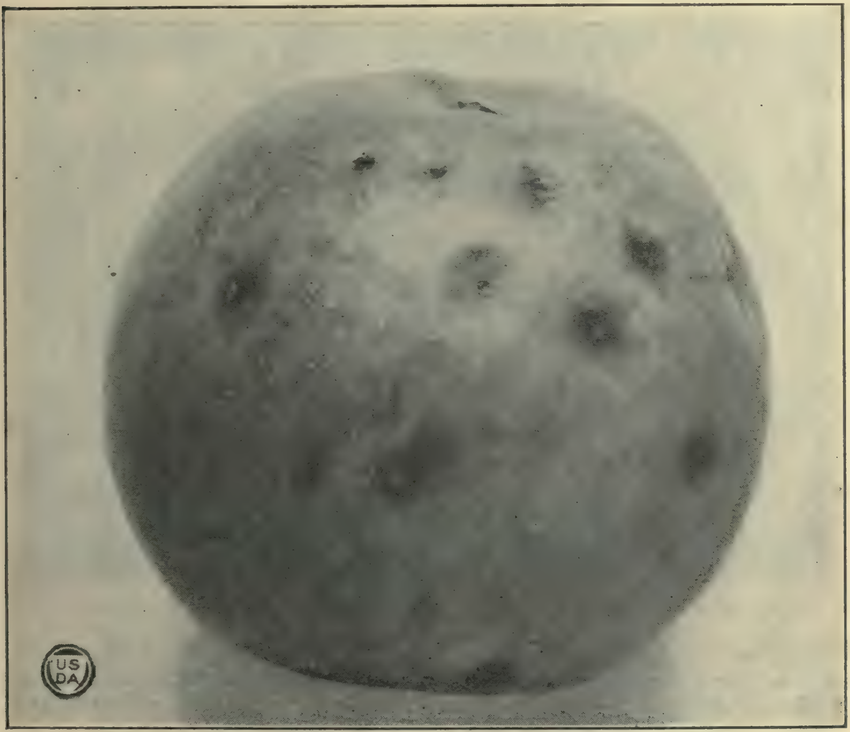

FIG. 4.—" Stings " produced by codling moth worms on apples.

SEASONAL HISTORY.

In order to control the codling moth, it is essential to understand the seasonal history of the pest, not only in general, but also under local conditions. The pictorial diagram given in Figure 6 will aid in following its activites through the season.

WINTERING WORMS.

The codling moth spends the winter as a worm in a cocoon. The wintering worms include all of the last brood of worms which develops during the year, and a part of the preceding brood, the percentage of wintering worms of the earlier brood being the smaller.

SPRING PUPÆ AND MOTHS.

With the coming of warmer spring weather, the wintering worms change to pupæ and later to moths, the latter beginning to appear soon after the apple trees are in bloom. The pupæ and moths which develop from the wintering larvæ are called the "spring brood of pupæ" and the "spring brood of moths." The moths of the spring brood, under normal conditions, reach the height of their activity in the Pacific Northwest during the last week in May or the first week in June. When the temperature in the late afternoon or evening is 60° F. or higher, the moths lay eggs.

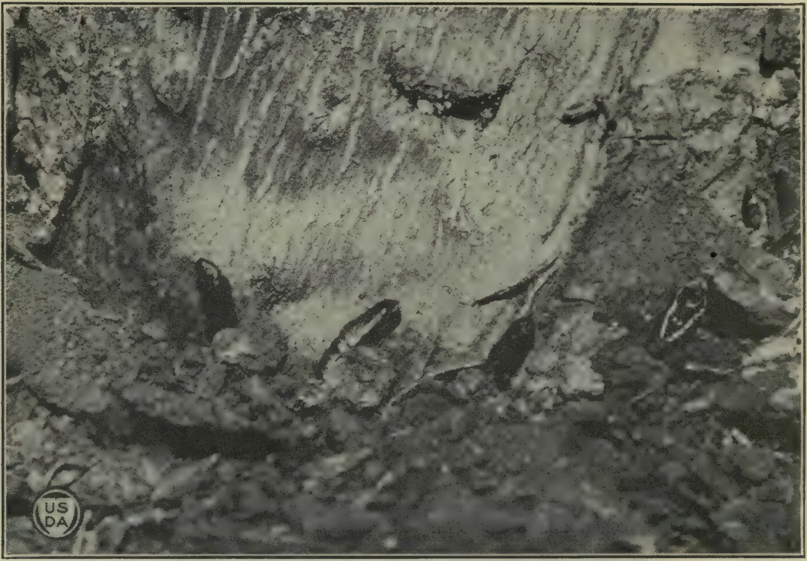

FIG. 5.—Empty pupal cases of codling moth protruding from cocoons at base of tree.

The dates given in Figure 6, as well as those in the text, are only approximate and will vary with the locality and season.

FIRST GENERATION.

The first generation begins with the eggs laid by the spring brood of moths and includes the worms, pupæ, and moths resulting from them. The earliest eggs are commonly subjected to considerable cool weather and the worms are not hatched for 12 to 14 days. As the temperature becomes higher, the length of the incubation period of the egg decreases, the minimum being 5 days. Newly hatched worms of this generation, that is, the first-brood worms, are found

entering the fruit for a period of about five weeks, and are most numerous about the middle of June.

The worms constituting the first brood feed in the fruit for about three weeks. Then, having reached their full growth, they leave the fruit and busy themselves for five or six days in making their cocoons. About 75 per cent of these worms continue their development into pupæ and moths, but the others remain in their cocoons until the following season. With the higher temperatures, the worms that transform pass through the pupal period in about two weeks, less than half the time required by the pupæ constituting the earlier spring brood.

The first individuals of the first brood of moths appear early in July and after this time moths are present in large numbers until cool weather, a period of about 10 weeks. The complete life cycle of the first generation, from the time the egg is laid until the resulting moth is prepared to lay eggs, is accomplished in 50 to 60 days.

SECOND GENERATION.

Many eggs of the second generation develop in six or seven days. and the young worms, appearing first about the middle of July, continue to attack the fruit in large numbers for about six weeks. These second-brood worms remain in the fruit to feed for a longer time than do the worms constituting the first brood, their average feeding period being about a month, and most of them will not change to pupæ and moths until the next season.

After leaving the fruit, the worm chooses its winter quarters and spins a cocoon. In the Rogue River Valley of Oregon and in some parts of eastern Washington a small number of these worms pupate and develop into moths of the second brood, which deposit a few third-brood eggs.

OVERLAPPING OF GENERATIONS.

The lower half of Figure 6 shows the average period which is covered by each stage of the codling moth. At certain times all stages are present, owing to the overlapping of generations. The first generation is the most uniform and is completed by the largest number of individuals. The stages of the second generation follow closely those of the first, though the corresponding stages of successive generations seldom overlap. Except for a short interval just before the middle of July, worms are hatching and attacking the fruit from the latter part of May to October.

NATURAL CHECKS ON CODLING MOTH INCREASE.

The worms of the codling moth while in their winter cocoons are subject to various unfavorable conditions. The weather is perhaps the most important of these. The worms will stand a great deal of cold, having been always accustomed to the same environment as the apple and pear trees. A temperature of a few degrees below zero will often kill 4 or 5 per cent of the worms not protected by snow or by the soil, and temperatures of 25° F. below zero or colder will kill practically all of the exposed worms. Many worms spin their cocoons in the soil or near the soil surface, where they are ordinarily protected by snow, and even these very cold temperatures will fail to reduce the numbers of worms materially. More worms will be killed by alternating periods of freezing and thawing than by a long period of freezing weather. In the spring unfavorable weather may hinder the development of the codling moth. Cold weather during the time the moths are flying may prevent them from depositing as many eggs as in warm weather. Birds also have a part in destroying the wintering worms.

At the present time insect enemies of the codling moth apparently are not of any great importance in the Pacific Northwest. A few beetles prey on the worms, and occasionally some eggs are found to be parasitized by a minute four-winged fly,[2] but for the most part the codling moth is free from attack by other insects.

IMPRACTICAL MEASURES FOR CONTROL.

Since many valueless methods for the control of the codling moth are continually being proposed, it seems necessary to mention some of them here in order to show why they are of no practical use.

Trap lights.—Trap lights are frequently suggested to catch the moths. They are worthless for the reason that the codling moth is not attracted to lights to any extent. In this respect it differs from many of the night-flying cutworm moths, which may be attracted to lights in numbers.

Baits.—Various baits have been tried, such as cider, or vinegar and water, placed in pans or jars in the orchard. Tests of these baits have shown that, while a few codling moths are attracted to them, the numbers thus caught are too small to warrant the necessary expenditure of time and money. Many beneficial insects are also caught.

Sprays.—Nicotine sulphate, or tobacco extracts, have been tested against the codling moth. These materials, in forms available at present, have been shown to be inadequate in killing either the eggs or the worms. Lime-sulphur has very little effect on the worms, either as a contact insecticide or as a stomach poison. Fruit growers should avoid the use of new and untried preparations or sprays, as in the great majority of cases these prove to be worthless.

Cultivation.—Since many codling moth larvæ enter the soil to spin their cocoons, it has been thought that cultivation would be of some value in destroying these. The evidence at hand tends to show that the great majority of these worms enter the soil at the tree trunk and spin their cocoons in contact with the trunk or larger roots. It would therefore be impracticable to destroy any of these cocoons by cultivation. Clean cultivation of an orchard has no effect in reducing the number of worms.

METHODS OF CONTROL WHICH SUPPLEMENT THE USE OF SPRAYS.

Planting and pruning.—From the standpoint of codling moth control it is advisable, when setting out a young orchard, to plant each variety in blocks of from four to six rows, rather than in alternating rows. This will make it possible to spray the earliest varieties first, and the others later, and will facilitate handling the fruit. Trees should be planted at such a distance apart that the spray machine can be driven between the rows at any time. The branches of adjacent trees should never interlock, as this interferes with thorough spraying. When the trees are pruned, the necessity of subsequent spraying should be considered, and the trees kept open enough to permit all parts to be reached with the spray. The tops of high trees are very difficult to spray properly, as well as expensive to pick. Consequently, trees should not be allowed to grow to extreme heights.

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[2] *Trichogramma minutum* Riley.

Thinning the fruit.—Many if not most of the first brood of worms that escape being poisoned by the spray may be destroyed by proper thinning of the fruit. All clusters should be thinned to one fruit, preferably the largest, as the worms find it much easier to enter where two fruits are touching, and usually both fruits are damaged. All fruits already wormy should be removed, and these should not be dropped to the ground, but should be destroyed. This wormy fruit may be fed to hogs, or thrown into a barrel or tank of water to which a little fuel oil has been added, or it may be burned, or buried under 6 inches of closely packed soil.

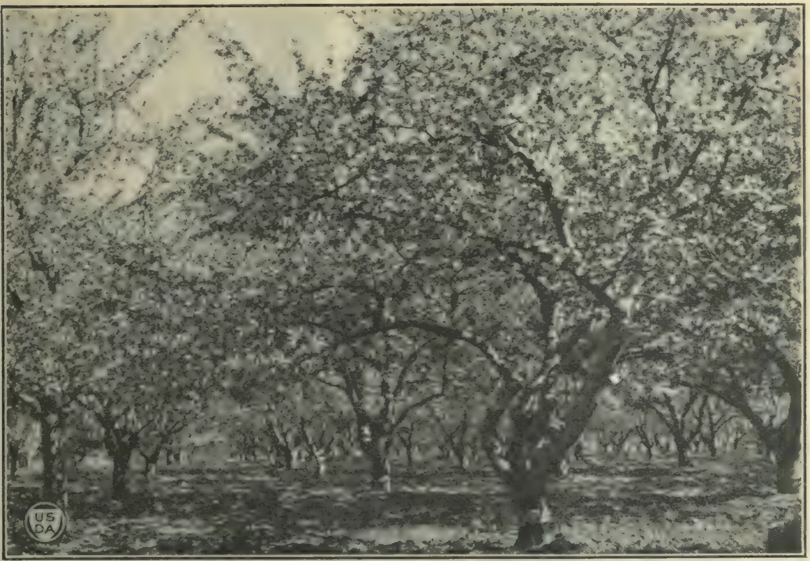

Fig. 7.—Apple orchard with trees banded for the codling moth.

To destroy the maximum number of worms, thinning should be done early—that is, in June—because the worms begin leaving the fruit during the last week of June. If the thinning is delayed until July, many of the worms will have left the fruit and will escape destruction. Early thinning is good orchard practice for other reasons, as it relieves the trees of the unnecessary load at the earliest possible time, and gives the remaining fruit a better chance for development.

Banding the trees.—Banding the trees with cloth bands in order to catch the worms has long been practiced, and this method of control has its uses (fig. 7). *Banding should never take the place of* *spraying*, but it is often a valuable help in reducing the number of worms in a badly infested orchard. Under the most favorable conditions, not more than one-third of the total number of worms will be caught in bands, and in orchards where the worms are being held in check effectively by spraying and thinning, banding is a useless expense.

To make banding most effective, the trees should first be scraped very thoroughly to remove all the loose bark under which cocoons might be spun. This should be done during the winter or early spring, when many wintering worms will be destroyed. A triangular box scraper or an old, well-sharpened hoe with a short handle may be used, or a suitable tool may be made from a mower section (fig. 8). All dead wood should be removed, and all cracks and holes filled up as far as possible. This will force more of the worms to spin their cocoons under the bands.

The bands may be made of any heavy cloth, burlap from old sacks being perhaps the most available and satisfactory material. Strips should be cut a foot wide and long enough to extend once around the trunk and overlap a little. These strips should be folded lengthwise, making a band about 6 inches wide. The bands are held in place by finishing nails or other nails with the heads nipped off. One or two of these nails should be driven into the tree where the ends of the band overlap, leaving only enough of the nail protruding to hold the band nicely.

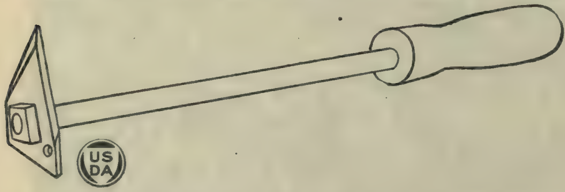
FIG. 8.—Scraper for removing bark from trunk of apple tree preparatory to applying band.

These bands must be in place by the middle of June. Beginning July 1, and every 10 days thereafter until September 1, the bands should be removed from the trees and examined, and all worms and pupae found in the bands or on the trunks of the trees destroyed. Worms coming into the bands after this date remain there for the winter, and it is not necessary to remove them until the fruit has been harvested. At any convenient time after harvest, the bands should again be removed and all worms destroyed. The bands may then be put away for the winter to be used again the following season. If it is only desired to catch the wintering worms, the bands should not be put on the trees until August 1, and a single examination after harvest is all that is necessary. *Banding should not be practiced unless the grower examines the bands systematically as recommended.*

SPRAYING THE MAIN RELIANCE FOR CONTROL.

The efficacy of spraying the fruit to protect it from the codling moth is so great that this method of control far outweighs in importance all the other methods put together. The maximum efficiency in spraying for the codling moth is not as easily attained as in spraying for other pests, because more sprays are necessary, and the time of application is of more importance. Hence careful work is required.

EQUIPMENT FOR SPRAYING.

SPRAYING OUTFITS.

No commercial orchardist should be without a power spraying outfit. It is usually an expensive matter to hire the spraying done; the work is slighted or done at the wrong time, and the results are poor. Often adjacent growers with small acreages can combine in the purchase of an outfit, and spray their orchards jointly. The number of acres a single outfit can cover will depend on the type of outfit, distance to water, efficiency of the operators, size of trees, and the lay of the land. It should be possible to apply an average of 8 to 10 tanks of spray in a 10-hour day. In general, enough outfits should be provided to complete any particular application of spray in a week or 10 days.

Many types of outfits are on the market, and the grower has a wide variety to choose from. Spray outfits usually receive severe treatment and a machine should be purchased that is known to be durable and as free as possible from mechanical faults. The engine on the machine should be of sufficient horsepower to operate the pump easily. An engine that is too small will cause a great deal of trouble. In deciding on the size of the machine, the grower must be guided largely by the size of his orchard. Some of the larger outfits are giving very good service and are undoubtedly worth the added cost to the man who has a large orchard.

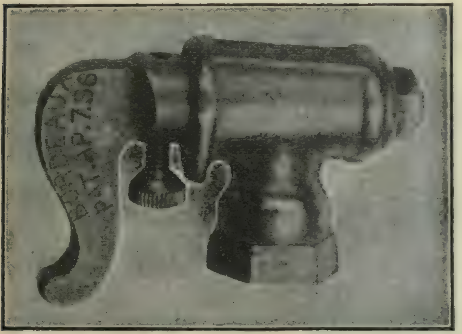

FIG. 9.—Bordeaux nozzle. (Quaintance and Siegler.)

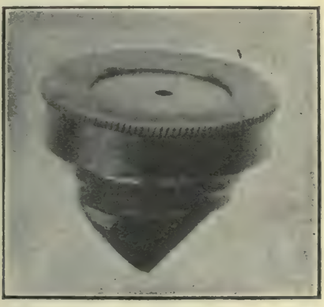

FIG. 10.—Angled nozzle of the eddy-chamber or whirlpool-disk type. (Quaintance and Siegler.)

Stationary systems for spraying are slowly coming into favor, and are worthy of investigation by the progressive fruit grower. Pipes are laid in the orchard at suitable intervals, with frequent outlets to which the hose may be attached. These pipes are connected to a pump which is housed at some convenient point and is operated by a gasoline engine or an electric motor. The initial outlay is relatively great, but the system should last longer than the usual outfit, because it is free from wear and tear caused by hauling about the orchard and over irrigation ditches. The use of a stationary system also makes it possible to spray any part of the orchard at any time, weather permitting, regardless of the condition of the soil, load on the trees, presence of props, or other things that sometimes interfere with driving a portable outfit through the orchard.

DUSTING OUTFITS.

A small acreage of young trees or a few trees about the house may often be most conveniently treated for the codling moth by using a mixture of dry powdered arsenate of lead and hydrated lime in a hand duster. Power dusters are on the market for large operations, but dusting is not recommended for the commercial orchards of the Pacific Northwest.

ACCESSORIES.

The spray hose should be of the best grade, preferably one-half inch inside diameter, and it is most conveniently handled if in lengths of 50 feet. Couplings and clamps should be heavy and properly adjusted so that there will be no leaks and no danger of coming apart. For most spraying operations two leads of hose are used. Three leads may be employed where one operator sprays from the tank or tower. Four leads are likely to be inconvenient, as the operators get in each other's way.

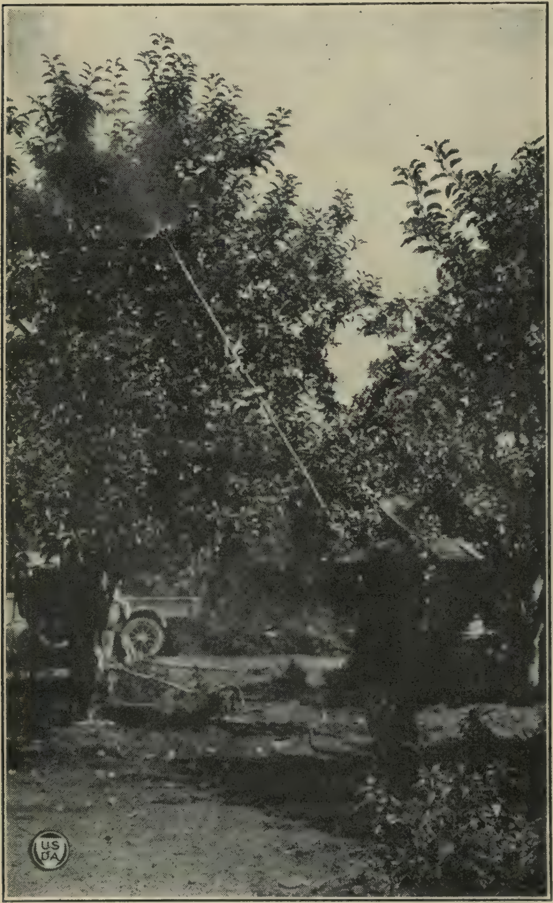
FIG. 11.—Spray rod equipped with two angled nozzles on a Y.

Either rods and nozzles or spray guns may be used in spraying for the codling moth. Good results will be obtained with either if they are properly used. If rods and nozzles are used, the rods should be of light weight so as not to tire the operator readily. A tired operator is a careless sprayer. Two types of nozzles are commonly used, the Bordeaux nozzle (fig. 9), which delivers a coarse, driving spray, and the whirlpool or cyclone type (fig. 10), which delivers a whirling, mistlike spray. The former is used chiefly for the calyx application, and the latter is used for all applications. An angled nozzle should be used, or an elbow with a straight nozzle, as a straight nozzle on the end of a rod is very awkward to handle.

If the outfit is large enough, two such nozzles may be attached to each rod by means of a Y (fig. 11).

Spray guns are without doubt more popular than rods. They are lighter and more easily handled. Spraying is more rapid with the guns and hence more economical, but careless work is more likely to be done than with the rods. The spray guns have the advantage of being adjustable, so that a wide cone of spray may be used for close-range work, or a long stream for greater distances (figs. 17 and 18). This adjustable feature should be utilized, the aim being at all times to reach the fruit to be sprayed and no farther. In purchasing a spray gun, one should be chosen in which the adjustment is made by a short turn of the handle. Durability should also be considered, as some spray guns get out of order easily. The disks for the guns and for the whirlpool nozzles come with different-sized holes, and the size to use will depend on the pressure supplied by the pump. New disks should be substituted when the holes in the old ones wear too large.

If the trees are high, one of the operators should spray from the tank or from a tower (fig. 12), as he can see better how he is applying the spray. The tops of large trees sprayed from the ground are often very poorly sprayed. The tower may be of wood or iron, and with a platform surrounded by a railing or with a frame in the shape of a carpenter's horse which may be straddled by the operator.

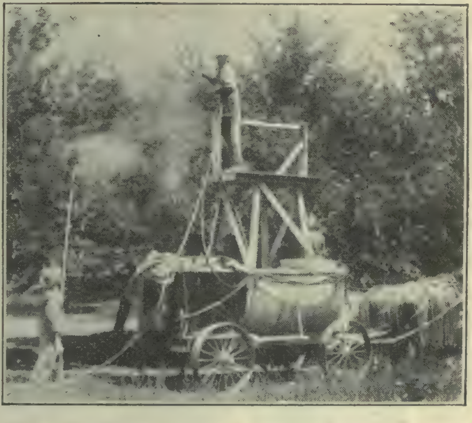

Fig. 12.—Power sprayer equipped with a tower. (Quaintance and Siegler.)

SPRAY MATERIALS.

ARSENATE OF LEAD.

Arsenate of lead is the standard insecticide used in spraying for the codling moth. At present no other insecticide approaches it in effectiveness or safety. Its chief fault is that it is a rather slow-acting poison. The codling moth worm burrows into the fruit in a short time, and even though it consumes a killing dose of poison in doing so, a "sting" (fig. 4) is produced before the worm dies. These stings are undesirable, as they lower the grade of the fruit. No insecticide has been found that will kill the worms so quickly that they are unable to produce stings. The only way to avoid stings is to keep the number of worms down to a minimum.

Arsenate of lead may be procured in either the powdered or the paste form. One form is as effective as the other, but the powder is more commonly used, as it is more convenient to handle and may be stored without danger of freezing. It does not lose its strength if kept from one season to another. According to the Federal insecticide act of 1910, paste arsenate of lead must contain at least 12.5 per cent of arsenic oxid (As_2O_5), and since the paste is usually nearly 50 per cent water, the powder should have at least 25 per cent of arsenic oxid. In fact, most brands on the market contain about 30 per cent and a statement of the arsenic content appears on the package. The insecticide act practically insures that any brand of arsenate of lead which has been on the market for some time and enters into interstate commerce contains the required amount of poison.

For the codling moth spray use the powdered arsenate of lead at the rate of 1 pound to 50 gallons of water, or the paste form at the rate of 2 pounds to 50 gallons of water. Larger amounts are unnecessary, and it is not considered safe to use smaller amounts. In using the paste, the required amount of poison should first be mixed with a small quantity of water and worked into a thin paste. Powdered arsenate of lead on the other hand should be washed into the tank through a sieve while the tank is being filled.

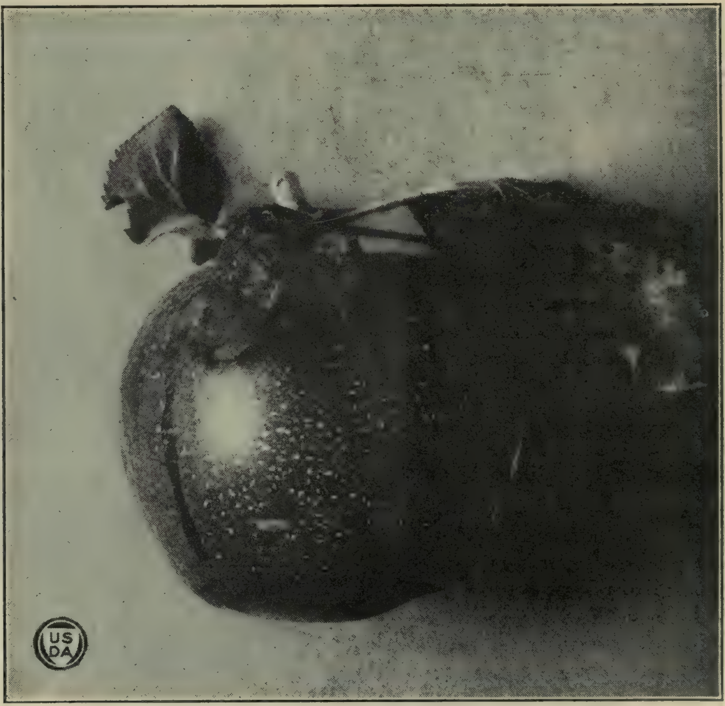

FIG. 13.—Apple covered with fine drops of spray.

OTHER ARSENICALS.

Magnesium arsenate, calcium arsenate or arsenate of lime, and Paris green have been used as codling moth sprays, but are not as desirable or as safe for the foliage as the arsenate of lead.

SPREADERS.

The mixture of arsenate of lead and water, when sprayed on the fruit and foliage of a tree, does not spread as evenly over the surface as is desirable. The liquid tends to collect in drops (figs. 13 and

14), and much of it rolls off altogether. To overcome this, certain materials may be added to the spray in the tank which will cause the spray to spread and wet the surface more thoroughly (fig. 15). These materials are known as spreaders.

The use of spreaders in codling moth spraying is relatively new, and there is much to be learned regarding them. So far as known at present, a spreader is a desirable addition to the arsenate of lead spray. It is possible to control the insect just as thoroughly without a spreader as with it. It is somewhat easier, however, to give the fruit a complete coat of poison when a spreader is included. Without a spreader, the tendency is to overspray, that is, spray until the material collects in relatively large drops, with areas between the drops partially or completely unprotected. With a spreader there is no difficulty in completely covering all parts of the fruit that are hit by the spray.

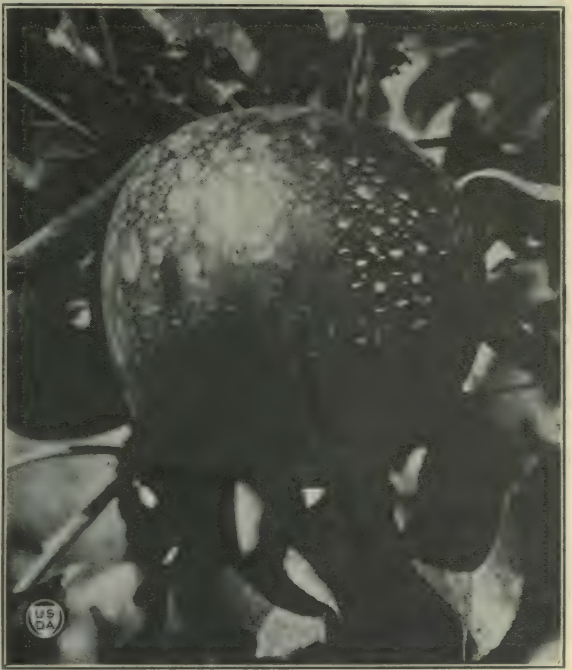

Fig. 14.—Apple oversprayed until coarse drops have formed.

The spreader will not cause the spray to spread around to the opposite side of a fruit. The opposite side must be sprayed. Neither can a spreader be depended on to make the material go farther. The addition of a spreader to the arsenate of lead has the advantage of eliminating the conspicuous white blotches that usually appear on fruit sprayed with the arsenical alone (fig. 14). These interfere with the proper coloring of the fruit, and sometimes make it objectionable to prospective purchasers. Chemical analyses show that there is just as much poison on an apple when a spreader has been used as when it has not. The difference is that the poison is more evenly distributed.

Many materials have been tested for use as spreaders, and among the best of these are soap, certain oil emulsions, glue, and casein. Some kinds of soap seem to make almost ideal spreaders, but at present they are not put up in convenient forms and they are more expensive than casein. Glue, while inexpensive, is also inconvenient, and some kinds of glue may not work well.

Casein is by far the most satisfactory spreader obtainable at present. In its pure form it does not mix with water, and it must be combined with an alkali before it can be put into the spray tank. One method consists of thoroughly grinding and mixing together certain proportions of casein and hydrated lime. It is not very easy for the fruit grower to do this, but a number of manufacturers have taken up this method of producing a spreader, and have put their products on the market. These products appear under various trade names, but are usually spoken of as "casein spreader," or more technically as "calcium caseinate" or "lime caseinate." The brands on the market at present contain from 15 to 25 per cent of casein. Ordinarily 1 pound of this prepared spreader to 200 gallons of spray is sufficient. This powdered material does not mix with water as readily as the arsenate of lead and must be washed slowly through the sieve of the spray tank, preferably while the tank is being filled. It may be put in either before or after the arsenate of lead is added.

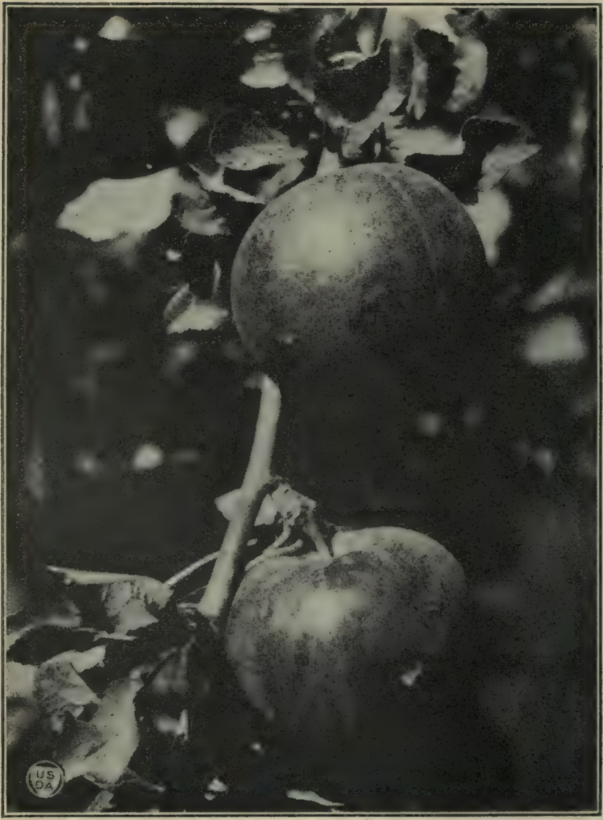

FIG. 15.—Apples sprayed with arsenate of lead to which a casein spreader has been added.

The grower may make up his own casein spreader if he desires, at a cost somewhat less than that of the prepared products. The most convenient method employs the following formula:

Water	1 gallon.
Caustic soda (common lye)	3 ounces.
Powdered casein	1 pound.

Bring the water to the boiling point, add the caustic soda, and as soon as this has dissolved, sift the casein in slowly, and stir thoroughly to avoid lumps until dissolved. Use 1 pint of this mixture to each 100 gallons of spray. This mixture will keep only a few days and must be made up fresh as needed.

Certain manufacturers have advertised the presence of a so-called "spreader" in their brands of arsenate of lead, and as this has caused some confusion in the minds of the growers, it seems advisable to mention this matter. Arsenate of lead, when mixed with water, does not dissolve in it to any great extent, but merely remains in suspension, and is kept from settling by the agitation of the spray in the tank. The particles are so finely divided that they settle very slowly even when agitation is discontinued. Some manufacturers have thought it advisable to further delay this settling by adding to their product small quantities of a substance that will cause the particles to "spread" apart in the water. This substance does not cause the arsenate of lead to spread over the surface of the foliage or fruit to any noticeable extent, and it is confusing to apply the term "spreader" to it.

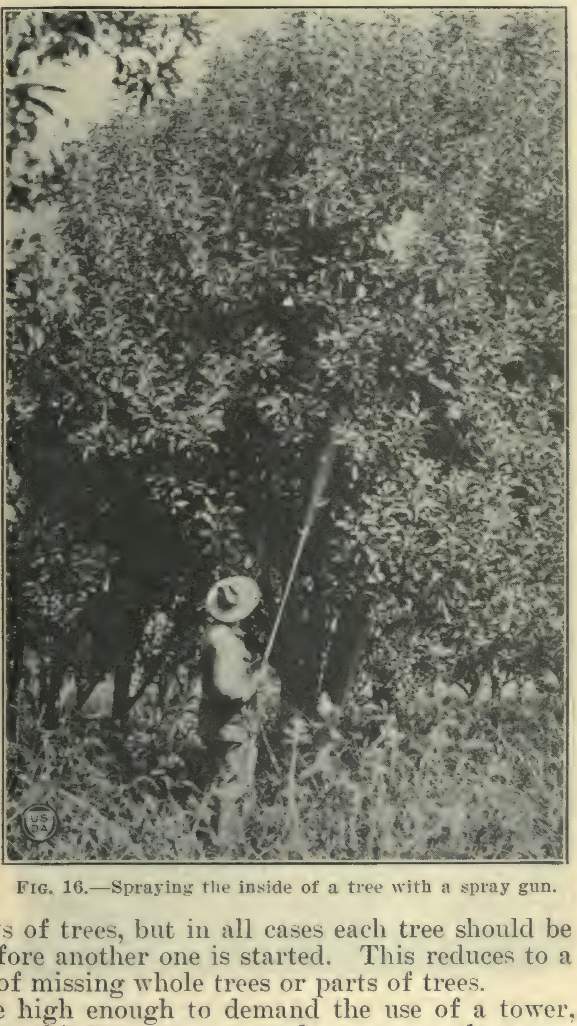
FIG. 16.—Spraying the inside of a tree with a spray gun.

HOW TO SPRAY.

The equipment for codling moth spraying usually includes two leads of hose. The spraying outfit is driven down the middle between two rows of trees and each operator, working from the ground, sprays one row, spraying each tree on all sides. Where trees are closely planted it is often possible for each man to spray two rows of trees, but in all cases each tree should be completely sprayed before another one is started. This reduces to a minimum the chances of missing whole trees or parts of trees.

Where the trees are high enough to demand the use of a tower, it is necessary to have a third operator, or to have one on the tower and one on the ground (fig. 12). In either case, the man on the tower sprays the upper part of each tree, and the man or men on the ground spray the lower part.

In spraying trees for the codling moth, particular attention is paid to the fruit. The foliage need not be completely covered unless the spray is being applied also for the powdery mildew, for scab, for aphids, or for other leaf-inhabiting pests. Too much emphasis can not be placed on the necessity of thorough work. The operator should commence by spraying the fruit on the inside of the tree (fig. 16), standing close to the trunk. He should then spray the outside fruit, starting at any convenient point and going completely around the tree.

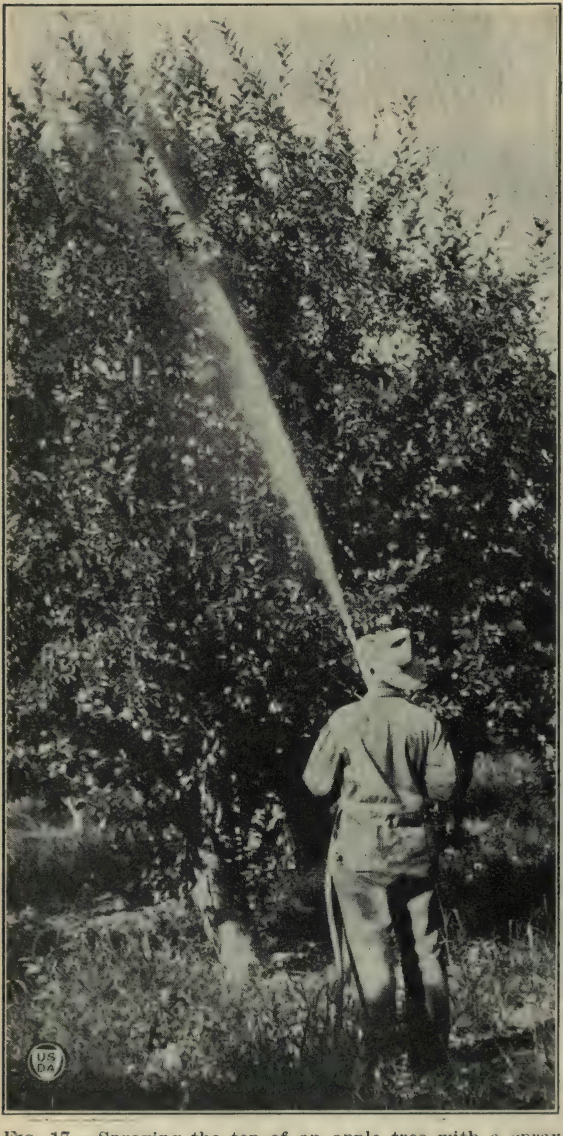
FIG. 17.—Spraying the top of an apple tree with a spray gun.

Each fruit should be sprayed from at least two sides, as the spray will not creep around the fruit, even when a spreader is used. It is impossible to spray more than two-thirds of a fruit from any one point. If no spreader is used, spray the fruit until it is covered with fine drops (fig. 13), but no longer. This will be easier if the nozzles or guns are producing a fine mistlike spray. It is wasteful and less efficient to spray until coarse drops form (fig. 14), as by this time the spray is dripping to the ground and large unprotected spaces are left on the fruit between the coarse drops. The use of a spreader makes it much easier to obtain a complete covering of the fruit (fig. 15). Pay particular attention to the fruit in the tops of the trees (fig. 17). The mist which a gun throws out between the operator and the top of the tree often deceives him. When spraying the lower limbs with a gun, it should be adjusted to produce a wide cone of misty spray, which will just reach the fruit (fig. 18).

The pressure necessary will vary with the equipment. Whether nozzles or guns are used, sufficient pressure should be supplied to form a fine mistlike spray, particularly for the cover sprays. If enough pressure can not be supplied to do this, the number of nozzles used, or the size of the holes in the disks, will have to be cut down until this type of spray is produced. With the smaller nozzles a proper spray will result with less than 200 pounds pressure. With guns and large-holed disks, 300 or more pounds may be required.

The amount of spray necessary to spray a tree thoroughly varies greatly. In general, thrifty 15-year-old apple trees with a full crop of fruit will require from 5 to 6 gallons of spray for the calyx application and from 4 to 5 gallons for the cover applications.

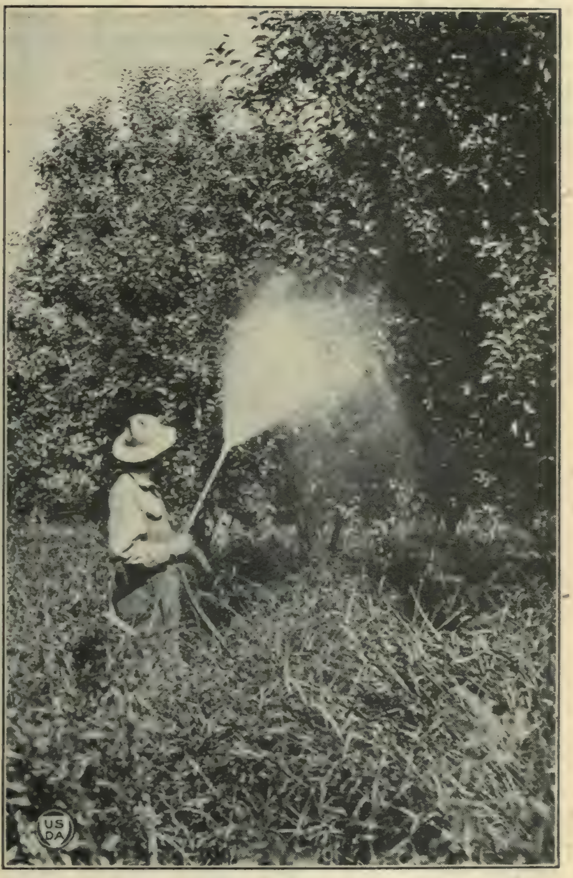
FIG. 18.—Spraying the lower limbs of an apple tree with a spray gun.

WHEN TO SPRAY APPLES.

It is of the utmost importance that the various codling moth sprays be applied at the proper time, since a spray applied at the wrong time may be largely wasted, and the fruit may be left unprotected when large numbers of worms are hatching. It is more difficult to ascertain the proper time for applying these sprays than for any of the other sprays used by the fruit growers of the Pacific Northwest, as the time differs from year to year.

The various other orchard operations, such as irrigating, cultivating, and thinning, should not be allowed to interfere with the spray schedule. The handling of alfalfa in the orchard often seriously disrupts the spraying program. This should not be the case. The best orchard practice does not favor cutting alfalfa for feed. This procedure removes valuable tree food from the orchard. If the alfalfa is cut, it should invariably be cut and removed from the orchard just prior to an application of spray, regardless of its condition for hay, thus obviating danger of poisoning stock. The alfalfa as a crop is secondary in importance to the fruit.

CALYX SPRAY.

The calyx spray is applied for the purpose of poisoning the calyx cups or blossom ends of the apples, in readiness for the worms of both the first and second broods when they appear. Usually more than half of the total number of worms enter the apples through the calyx cups. This is the most important spray of all and should be very thoroughly applied, every calyx cup being filled. Some growers consider it advisable to apply two calyx sprays, one right after the other, but if thorough work is done this is not ordinarily necessary.

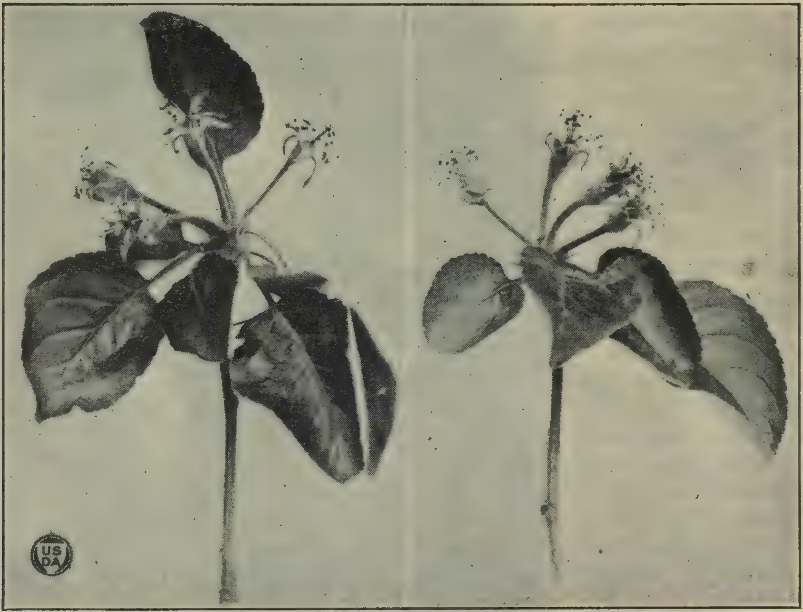

FIG. 19.—Apple blossoms from which petals have just fallen; the right time to make "calyx spray" for the codling moth. (Quaintance and Siegler.)

The time to put on the calyx spray can best be determined by the individual grower. It must be applied between the time the petals fall and the time the calyx cups close, a period of not more than 10 days. Spraying should begin as soon as most of the petals have dropped (fig. 19), and should be completed before many of the calyx cups have closed. It is often possible to spray the earlier blooming varieties first and then the later ones. *Do not spray while the trees are still in bloom, as injury may result to the blossoms or to the bees that visit them, and do not wait until the calyces have begun to close* (fig. 20).

COVER SPRAYS.

The cover sprays are for the purpose of coating the surface of the apples with poison to prevent worms entering the side. The number of cover sprays necessary will vary with the locality and the degree of worminess of the orchard. In the great majority of apple orchards in the Pacific Northwest four cover sprays should be used, two for the first brood and two for the second brood, following spray schedule 5 in Table 1, or Table 3. This procedure will be described first, and variations from it mentioned later. Every effort should be made to eliminate as far as possible the first brood of worms, and the spraying for this brood should be unusually thorough, even though few wormy apples are seen. The second brood of worms are all the progeny of the first brood, and the nearer the grower comes to eradicating the first brood the less trouble he will have with the second brood.

SPRAYS FOR THE FIRST BROOD.

First cover spray.—The first cover spray is put on to kill the earliest worms of the first brood, and is the most difficult to time properly. Most fruit growers are not equipped to make accurate observations of the habits of the codling moth, and can not tell in this way when to spray. If expert advice is not available, probably the best way to set this date is to observe the 8 p. m. temperatures of a thermometer hung in the orchard away from the buildings. Begin making observations as soon as the calyx spray is completed, and when two or more nights occur with 8 p. m. temperatures of about 60° F. or higher, plan to have the cover spray completed within 10 days. The reason for this is that these temperatures will cause the moths to lay eggs, as heretofore explained, and the eggs normally will hatch in about 10 days. The spray should be on the trees when the eggs are ready to hatch. This first cover spray will have to be applied almost invariably from two to three weeks after the calyx spray.

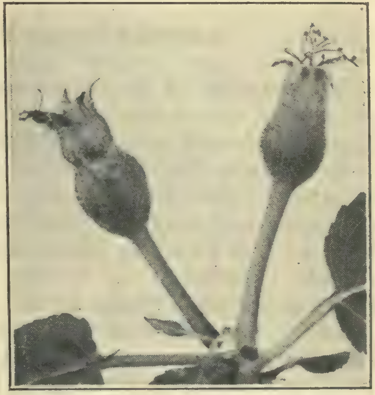

Fig. 20.—Too late for calyx spray.

Second cover spray.—The second cover spray for the first brood should be completed two weeks after the first one has been finished. This spray is for the purpose of providing a fresh coating of poison at the time when the largest number of worms are hatching. Do not delay this spray longer than two weeks after the first cover spray. The fruit is growing rapidly at this time and the worms are becoming more numerous. A delay may be costly. Under most circumstances no further spraying will be necessary for the first brood of worms.

SPRAYS FOR THE SECOND BROOD.

As there is an interval between the first and second broods of worms, there is no need of spraying again for about four weeks.

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Third cover spray.—This puts the third cover spray, or the first spray for the second brood, about six or seven weeks after the first cover spray. This spray usually comes between the middle of July and the 1st of August, and will poison the early worms of the second brood. If it is desired to time this spray more accurately, band a few wormy trees and spray 25 days after the first worm of the first brood appears under the bands. Unless the trees banded are quite wormy, however, this method will not be accurate.

Fourth cover spray.—The fourth cover spray, or second spray for the second brood, should come four weeks after the third cover spray, or about 10 or 11 weeks after the first. The apples do not grow as rapidly at this time as earlier, and the second brood of worms is more prolonged, hence the advisability of a longer interval between applications of spray. This application will ordinarily come between the 15th and the 31st of August, and under most conditions there is no object in a later spray. If the worms are not under control, a later spray can do little good, and will only result in excessive amounts of poison on the fruit at picking time. If careful work is done in putting on the earlier applications there need be no apprehension of a sudden influx of late worms.

VARIATIONS IN THE NUMBER OF SPRAYS.

The number of sprays necessary to control the codling moth may vary from one to six. At least half the total number of cover sprays, however, should be applied for the first brood of worms.

In certain favored localities in the Pacific Northwest, such as Whatcom County, Wash., the codling moth practically does not occur, and spraying may not be necessary. Farther south in Washington, west of the Cascade Mountains, the calyx spray alone may suffice (Table 1, schedule 1) or two sprays, the calyx spray and a cover spray about four weeks later (Table 1, schedule 2), may be required.

In the remainder of the Pacific Northwest, including Oregon, eastern Washington, and Idaho, the number of sprays necessary varies from one to six, depending on the altitude, climate, degree of codling moth infestation, and other factors. Table 1 gives spray schedules calling for from one to six applications, and the individual grower will have to determine from his own experience and that of others in his locality which schedule to follow.

SPRAY SCHEDULES FOR APPLES.

TABLE 1.—*Codling moth spray schedules for apples in the Pacific Northwest.*

Schedule.	Spray.	Time of application.
Schedule 1 (1 spray)	1. Calyx spray	When most petals have fallen.
Schedule 2 (2 sprays)	1. Calyx spray	Do.
	2. Cover spray	4 weeks after 1.
Schedule 3 (3 sprays)	1. Calyx spray	When most petals have fallen.
	2. First-brood cover spray	4 weeks after 1.
	3. Second-brood cover spray	6 or 7 weeks after 2.
Schedule 4 (4 sprays)	1. Calyx spray	When most petals have fallen.
	2. First cover spray	3 weeks after 1.
	3. Second cover spray	2 weeks after 2.
	4. Third cover spray	6 or 7 weeks after 2.

TABLE 1.—*Codling moth spray schedules for apples, etc.*—Continued.

Schedule.	Spray.	Time of application.
Schedule 5 (5 sprays)	1. Calyx spray	When most petals have fallen.
	2. First cover spray	3 weeks after 1.
	3. Second cover spray	2 weeks after 2.
	4. Third cover spray	6 or 7 weeks after 2.
	5. Fourth cover spray	10 or 11 weeks after 2.
Schedule 6 (6 sprays)	1. Calyx spray	When most petals have fallen.
	2. First cover spray	3 weeks after 1.
	3. Second cover spray	8 to 10 days after 2.
	4. Third cover spray	16 to 20 days after 2.
	5. Fourth cover spray	6 to 7 weeks after 2.
	6. Fifth cover spray	10 or 11 weeks after 2.

WHEN TO SPRAY PEARS.

Pears ordinarily do not become as wormy as apples, particularly when interplanted with them, the moths showing a preference for the apples. Where solid plantings of pears are made, the fruit often becomes decidedly wormy unless properly sprayed. In all cases, a calyx spray should be applied. As the pear calyces do not close rapidly, there is more time in which to apply this spray than in the case of apples.

Following the calyx spray, a cover spray should be given about four weeks after the petals have dropped. Where pears are interplanted with apples, these sprays may be applied at the same time the apples are being sprayed.

In the warmer sections, and where the worms are numerous, it is necessary to apply further cover sprays according to the seriousness of the infestation. Where the worms are unusually difficult to control, pears should be sprayed as often as apples. Bartletts or other early varieties should not be sprayed after the end of July, as they are usually harvested in August.

If only one spray is needed this may be applied at the time of the first cover spray for apples. This will act as a combined calyx and cover spray, because the calyx cups mostly remain open in pears until after this time (Table 2, schedule 1). If this one spray is insufficient, a calyx spray should be applied earlier, because pears are more subject to calyx worms than apples and need more protection in the calyx (Table 2, schedule 2).

In order to facilitate an even distribution of the spray over the smooth, waxy surface of the pears and to prevent the objectionable blotching of the mature fruit, it is advisable to use a spreader in the cover sprays.

Table 2 suggests schedules for pears differing in the number of applications.

SPRAY SCHEDULES FOR PEARS.

TABLE 2.—*Codling moth spray schedules for pears in the Pacific Northwest.*

Schedule.	Spray.	Time of application.
Schedule 1 (1 spray)	1. Combined calyx and cover spray	Just before worms begin to hatch.
Schedule 2 (2 sprays)	1. Calyx spray	When most petals have fallen.
	2. Cover spray	3 or 4 weeks after 1.
Schedule 3 (3 sprays)	1. Calyx spray	When most petals have fallen
	2. First cover spray	3 weeks after 1.
	3. Second cover spray	2 weeks after 2.

TABLE 2.—*Codling moth spray schedules for pears, etc.*—Continued.

Schedule.	Spray.	Time of application.
Schedule 4 (4 sprays)	1. Calyx spray	When most petals have fallen.
	2. First cover spray	3 weeks after 1.
	3. Second cover spray	2 weeks after 2.
	4. Third cover spray	7 or 8 weeks after 2.
Schedule 5 (5 sprays)	1. Calyx spray	When most petals have fallen.
	2. First cover spray	3 weeks after 1.
	3. Second cover spray	2 weeks after 2.
	4. Third cover spray	7 or 8 weeks after 2.
	5. Fourth cover spray	2 or 3 weeks after 4.

CONCISE DIRECTIONS FOR SPRAYING.

Own a good spraying outfit and keep it in good mechanical condition. It pays.

Have sufficient pressure to break the spray into a fine mist. If your outfit will not do this with the nozzles you are using, put in disks with smaller holes, or use fewer nozzles. Replace the disks as the holes become worn.

Use any standard brand of arsenate of lead, 1 pound of powder or 2 pounds of paste to 50 gallons of water. The use of a spreader is advisable.

Never omit the calyx spray. Put it on as soon as the petals have fallen. Spray very thoroughly and fill every calyx cup.

Apply as many cover sprays as necessary. Get expert advice as to the number necessary and when to apply them. If this is not available, use the recommendations contained in this bulletin. Be particularly thorough with the cover sprays for the first brood. Spray the entire surface of each fruit. Remember there is fruit in the center of the tree and in the top.

Do not apply very late sprays or use more than the standard amount of arsenate of lead. Either course may result in objectionable spotting of fruit at harvest time.

Hold to your spray schedule. Do not let other orchard operations interfere with it.

COMBINATION SPRAYING FOR THE CODLING MOTH, POWDERY MILDEW,[3] AND SCAB.

Prepared in cooperation with D. F. FISHER, *Pathologist, Bureau of Plant Industry.*

Apple powdery mildew is found on apples practically throughout the Pacific Northwest, while scab occurs only in the more humid sections such as west of the Cascade Mountains and in the hilly regions of eastern Washington and Idaho. As these two fungous diseases are combatted by spraying at approximately the same time as for the codling moth, it is very often convenient to combine the materials used and spray them on the trees together. This applies particularly to the calyx spray and the first two cover sprays.

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[3] For a full discussion of apple powdery mildew and fungicides to use for it, see Farmers' Bulletin 1120, Control of Apple Powdery Mildew.

A weak lime-sulphur solution (see Tables 3 and 4) is the fungicide most often used to control mildew and scab. It is entirely safe and practicable to mix lime-sulphur and arsenate of lead if certain precautions are observed. In mixing the sprays the lime-sulphur should be put in while the tank is being filled, and the arsenical added just before beginning to spray and while the spray solution is being vigorously agitated. It is also well to turn the nozzles into the tank for a minute or two before beginning to spray, to insure uniform mixing.

Because of a chemical reaction which occurs in the mixture the combined spray should be used at once, and not allowed to stand in the tank for several hours. This procedure will insure against the accumulation in the tank of a heavy black precipitate that is the result of the reaction and that might give trouble in the valves and screens of the machine. The reaction may be retarded by adding to the 200-gallon tank the milk of lime obtained by slaking 8 pounds of quicklime, but this is not necessary if the material is sprayed out promptly. A spreader, preferably casein,[4] should always be used in mildew spraying to effect a uniform covering of the foliage. This spreader will also retard the reaction between the lime-sulphur and the lead arsenate if put into the tank before either of the other ingredients is added.

In spraying for mildew or scab, more material must be used than where the codling moth alone is concerned, since both sides of the leaves must be thoroughly covered with the spray. The proper times to use the fungicides are indicated in Tables 3 and 4.

COMBINED SPRAY SCHEDULES FOR THE CODLING MOTH, POWDERY MILDEW, AND SCAB.

Prepared in cooperation with D. F. FISHER, *Pathologist, Bureau of Plant Industry.*

In Table 3 is given a spray schedule for the control of the codling moth in the arid irrigated sections of the Pacific Northwest. Recommendations for mildew spraying are added *in italics.* The first column in each section gives the character of the application and the time to apply it. The second column specifies the material to be used and the amount, while the third column shows the pest to be controlled by each material. The pink spray is for the mildew alone. If the interval between the calyx spray and the first cover spray is more than three weeks, which may occur in cool, wet seasons, a special mildew spray should be applied two weeks after the calyx spray, using the same spray as for the pink spray.

It is impossible to give special spray schedules for each section of the region covered by this bulletin, but the one given in Table 3 will be used by the majority of growers in the arid regions. There may be certain sections or certain orchards, as already explained, situated so favorably that fewer applications will suffice. On the other hand, growers in the warmest parts of the Northwest, or in very wormy localities, may find it necessary to apply three cover sprays for the first brood of worms instead of two, as indicated in schedule 6, Table 1.

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[4] Soap spreaders can not be used with lime-sulphur.

Table 4 gives a spray schedule to be used wherever scab is of sufficient importance to warrant control measures. This applies to the regions west of the Cascade Mountains, except the Rogue River Valley, and to some of the more humid sections in the eastern part of the region covered by this bulletin. In some of these districts, it will not be necessary to apply more than one or two sprays for the codling moth, though more may be required to control scab.

TABLE 3.—*Combined codling moth and powdery mildew spray schedule for the arid sections of the Pacific Northwest.*

Application and time.	Materials.	Pest controlled.
Pink spray: Apply just before the blossoms open.	*Lime-sulphur, 1 to 50; or iron sulphid*	*Apple powdery mildew.*
Calyx spray: Apply when most petals have fallen.	Lead arsenate, powder, 1 pound, or paste, 2 pounds, to 50 gallons of water. *Lime-sulphur, 1 to 50; or iron sulphid*	Codling moth. *Apple powdery mildew.*
First cover spray: Apply just before first worms are hatching. (About 3 weeks after calyx spray.)	Lead arsenate, powder, 1 pound, or paste, 2 pounds, to 50 gallons of water. *Lime-sulphur, 1 to 50; or iron sulphid*	Codling moth. *Apple powdery mildew.*
Second cover spray: Apply 2 weeks after first cover spray.	Lead arsenate, powder, 1 pound, or paste, 2 pounds, to 50 gallons of water. *Lime-sulphur, 1 to 50; or iron sulphid*:[1] *or ammoniacal copper carbonate.*[2]	Codling moth. *Apple powdery mildew.*
Third cover spray: Apply 6 or 7 weeks after first cover spray.	Lead arsenate, powder, 1 pound, or paste, 2 pounds, to 50 gallons of water.	Codling moth.
Fourth cover spray: Apply 10 or 11 weeks after first cover spray.	do	Do.

[1] Use if the infection is severe or the crop light.

[2] Use where the danger of burning the fruit is to be avoided.

TABLE 4.—*Combined codling moth, scab, and mildew spray schedule for the humid sections of the Pacific Northwest.*

Application and time.	Materials.	Pest controlled.
First cluster-bud spray: Apply when buds are bursting.	*Lime-sulphur, 1½ to 50*	*Scab.*
Pink spray: Apply just before the blossoms open.	*Lime-sulphur, 1½ to 50*	*Scab and mildew*
Calyx spray: Apply when most petals have fallen.	Lead arsenate, powder, 1 pound, or paste, 2 pounds, to 50 gallons of water. *Lime-sulphur, 1½ to 50*	Codling moth. *Scab and mildew.*
Ten-day spray: Apply 10 to 14 days after calyx spray.	*Lime-sulphur, 1½ to 50*	Do
First cover spray: Apply just before first worms are hatching (3 or 4 weeks after calyx spray).	Lead arsenate, powder, 1 pound, or paste, 2 pounds, to 50 gallons of water. *Lime-sulphur, 1½ to 50*	Codling moth. *Scab and mildew.*
Second cover spray:[1] Apply 2 weeks after first cover spray.	Lead arsenate, powder, 1 pound, or paste, 2 pounds, to 50 gallons of water.	Codling moth.
Third cover spray: Apply 6 or 7 weeks after first cover spray.	Lead arsenate, powder, 1 pound, or paste, 2 pounds, to 50 gallons of water.	Do.

[1] Apply this spray if codling moth infestation is severe or the season unusually warm.

ORGANIZATION OF THE UNITED STATES DEPARTMENT OF AGRICULTURE.

January 10, 1924.

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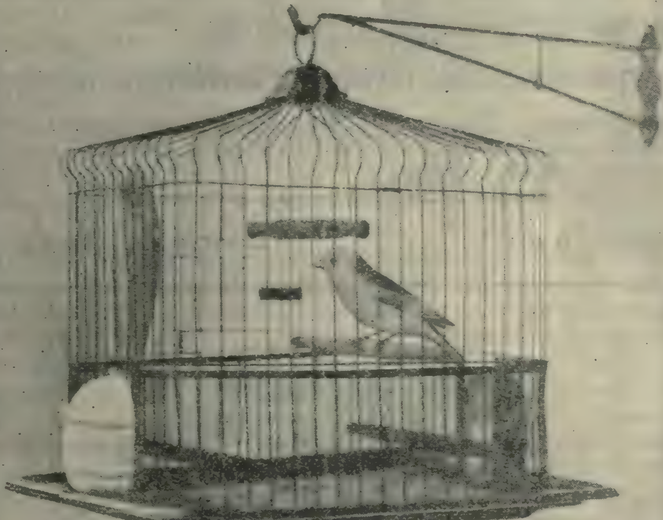
U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1327

CANARIES

THEIR CARE AND MANAGEMENT



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TO MEET the requests continually received for information on the care of canaries in sickness and health, this bulletin has been compiled from numerous sources, including personal experiences and observations of the author. It is intended for all who are interested in canaries.

This bulletin is a revision of and supersedes Farmers' Bulletin 770.

Washington, D. C. Issued May, 1923; revised April, 1924

CANARIES: THEIR CARE AND MANAGEMENT.

By **Alexander Wetmore**, *Assistant Biologist, Division of Biological Investigations, Bureau of Biological Survey.*

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INTRODUCTION.

AMONG THE BIRDS kept for household pets none is more common or better known than the canary. So simple are its requirements in the way of food and care that it needs little attention, and because of its pleasing songs and interesting habits it is a universal favorite. Readily adaptable to cage life, the canary displays little of the fear shown by wild birds in captivity, and the ease with which it may be induced to nest and rear young adds to its popularity.

Canaries have been domesticated for several hundred years and, though more common in western Europe and the United States than elsewhere, have been carried over practically the entire civilized world. In England and Germany there are hundreds of canary breeders and many avicultural societies. Several periodicals dealing solely with cage birds are published there, and in the larger cities bird exhibitions are held annually. Similar activities in the United States, while of younger growth, are making considerable progress.

During the 10-year period prior to 1915 more than 3,250,000 canaries were imported into the United States, mainly from Germany and England. With the continuance of the World War the number brought in decreased steadily, until it fell from an average of more than 1,000 birds per day in 1914 to about 10,000 for the year 1918. Importations from Germany practically ceased, and comparatively few birds were to be obtained from England, so that dealers were forced to look to the Orient, mainly to China, for the small number secured. This depression continued until 1920, but with return to more normal conditions in 1921, about 70,000 were imported, and in 1922 more than 150,000, largely from the former sources in Europe as well as from the Orient.

Canaries seem to thrive in any climate where not exposed to too severe weather conditions, and in spite of the long period they have been protected and held in captivity they are capable of enduring a surprising degree of cold when hardened to it. In England it is not unusual to find them in outdoor aviaries throughout the year, and in the comparatively mild climate of California they thrive under these conditions. They seem able to establish themselves again in a wild state under favorable circumstances. A few domestic canaries released in 1909 on Midway Island, a sandy islet in the Hawaiian group, increased rapidly and apparently are permanently established. They still seek the society of man, as in 1923 the present writer found them abundant in trees planted in the vicinity of the Midway Cable Station but did not observe them among the bushes that cover the wilder part of the island.

HISTORY.

The origin of the canary as a cage bird is as obscure as is the early history of other domesticated animals. It seems probable that captive canaries were first secured from the Canary Islands, a group with which they have long been popularly associated. There are in the Old World, however, two closely allied forms from which the domesticated canary may have come. One of these, the bird now recognized as the "wild canary," is found in the Canary Islands (with the exception of the islands of Fuerteventura and Lanzarote), Madeira, and the Azores. This form is illustrated in Figure 1. The other form, the serin finch,[1] ranges through southern Europe and northern Africa, extending eastward into Palestine and Asia Minor. In a wild state these two forms are very similar in color and to a novice are hardly distinguishable.

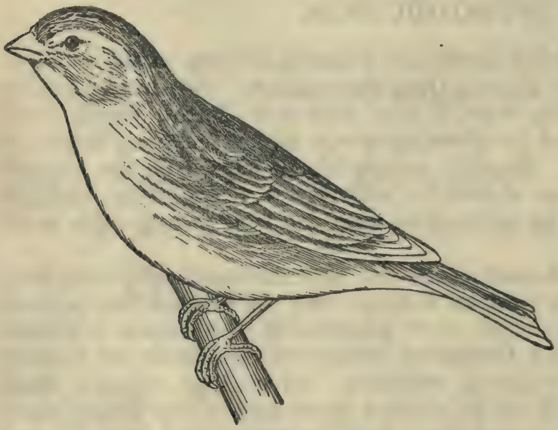

FIG. 1.—Wild canary.

If, as is supposed, the original supply of canaries came from the Canary Islands, it may be considered doubtful that the stock thus secured has furnished the ancestors of all our canaries. The slight differences in color between the serin finch and the canary would probably have passed unnoticed by early ornithologists and bird lovers. With bird catching a widespread practice in middle and southern Europe, the serin would often be made captive and be accepted without question as a canary. In this way serins and wild canaries may have been interbred until all distinguishable differences were lost.

The original canary, whether serin or true wild canary, in its native haunt was much different in color from its modern pure-bred descendant. The back of the wild bird is, in general, gray, tinged with olive-green, especially on the rump, with dark shaft streaks on the feathers. Underneath it is yellowish, streaked on sides and flanks with dusky. Wild canaries from the Canary Islands, the Azores, and Madeira differ from the Continental serins in being slightly grayer with less of yellowish green in the plumage above. In addition, the rump is duller yellow and the bill is distinctly larger. All the wild birds have the feet and legs (tarsi) horn brown, the upper half of the bill dark brown or horn color, and the lower half paler.

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[1] The scientific name of the serin is *Serinus serinus serinus*. The wild canary is known as *Serinus s. canarius*. Both were first described by Linnaeus.

Both of the wild varieties inhabit vineyards, thickets, and more open country where bordered by trees. At times, during fall and winter, great flocks are found together. The birds feed upon various seeds and occasionally eat figs or other small fruits in season. In a wild state they nest early in spring and again later, rearing two broods. The nest, made of plant stems and grasses and lined with hair and plant downs, is placed in bushes or low trees. The eggs are clear green in color, spotted and clouded with deep wine red and reddish brown. From three to five eggs are deposited.

VARIETIES.

Canaries were known in a domesticated state at the close of the fourteenth century, though they may not have been common, as Gesner, who wrote in 1555, said that he had never seen one. Variation among them began early, as partly yellow birds were known at Nuremberg in 1614, and in 1677 wholly yellow canaries (also a white variety) were recorded from Augsburg, in Germany, an early center for the fancy. The various forms have had their origin in distinct geographic areas, and though some are almost extinct at present, all at one time or another have had a devoted following of fanciers. At present at least 14 distinct strains, with a large number of varieties, are known.

The common canary is reared primarily for its song, and from it probably came the roller, or song canary, a great favorite in Germany and, more recently, in England and the United States. In rearing song canaries attempt is made to produce males with clear, soft, pleasing songs with long rolls or trills, and no attention whatever is paid to other characters. These birds, therefore, may be nondescript as regards color and appearance, and in mating care is taken only to secure males that are good singers and females from good stock.

The young birds when fledged are put in rooms with males noted for their soft song, and here, through imitation, they develop their own vocal powers. Careful watch is kept over them, and any bird that develops harsh notes is removed at once to prevent his corrupting the purity of tone in the song of his brothers. A mechanical instrument known as a bird organ, that produces liquid trills, is frequently utilized in training, usually when the adult birds are silent during molt. Ordinarily the room where song canaries are being trained is darkened, and frequently the cages containing the young birds are screened with cloth to lessen a tendency to objectionable loudness of song. In six months or less, their education completed, these songsters may be sold or in their turn utilized in training others still younger. It is common to teach these birds some simple strain or air, through its constant repetition by whistling or by means of an instrument. Well-trained birds are popular pets and frequently bring high prices.

In the class of exhibition birds, perhaps none is more striking than the Belgian canary, pictured in Figure 2. Formerly known as the "king of the fancy," it was reared extensively in Belgium, but of late years its popularity has been on the decline, so that as late as 1911 it was said that few pure-bred Belgians were to be found. The typical Belgian canary is a large bird with a small head, long, slender neck, large shoulders, and a long, tapering body. It is primarily a bird of "position." When assuming the peculiar and desired attitude the bird throws its shoulders up and brings the head down well below their level; the back and tail form a perpendicular line and the feet are held close together.

Another bird of position is the Scotch fancy canary, illustrated in Figure 3. This variety resembles the Belgian, but when in position throws the tail in under the perch until its outline in profile is almost a semicircle.

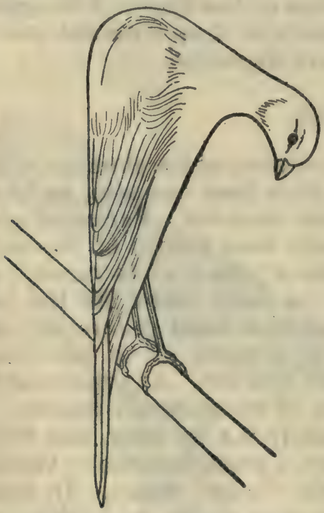
FIG. 2.—Belgian fancy canary.

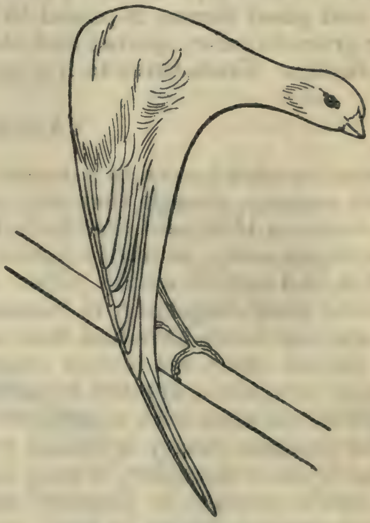
FIG. 3.—Scotch fancy canary.

Another well-marked variety is the cinnamon canary, one of the earliest forms to appear, but one whose origin is wholly unknown. Its true color is a dun or dull brown that has been likened to cinnamon. In exhibition birds the color is usually intensified by color feeding (see p. 14). The cinnamon canary is peculiar also in possessing red or pink eyes, a character that denotes cinnamon blood even in a yellow or buff bird. The cinnamon inheritance is transmitted only by the male; young reared from a cinnamon mother and a male of any other form lacking cinnamon blood never show signs of their cinnamon parentage.

Among the old-established varieties that now are in decadence none is more striking than the lizard canary. Lizard canaries are known as "gold" or "silver," according as the body color is yellow or silvery gray. The wings and tail are black and the back is spangled with numerous somewhat triangular black spots. The crown in pure-bred birds is unspotted and light in color, as shown in Figure 4.

The crested canary, pictured in Figure 5, is another unusual form, with a long crest that extends down around the head below the level of the eyes. Another, the frill or Dutch frill canary, is a large bird with long curling feathers. The Lancashire is the largest of known varieties of the canary, standing head and shoulders above all others. These "giant" canaries may be crested or smooth headed. Other forms that may be mentioned are the Border Fancy, a small bird; and the Norwich, or Norwich plain-head, from which come many of the common canaries.

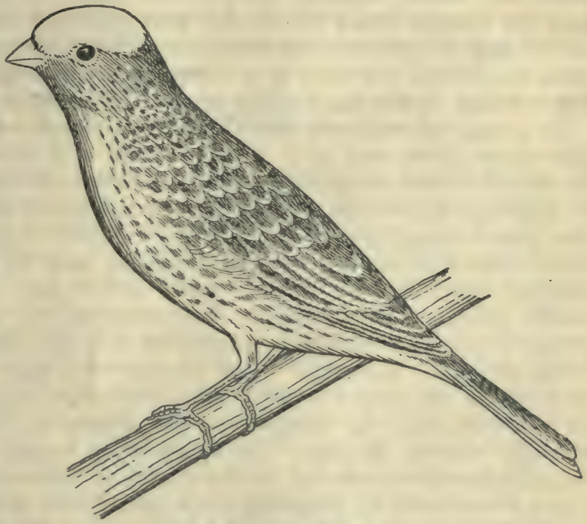

FIG. 4.—Lizard canary.

It must not be supposed that the varieties of canaries enumerated above cover the entire field. For each of the main forms there are almost endless groups or divisions that have been developed on color peculiarities. To obtain pure-bred birds requires constant care and supervision, and with any slackness of method hosts of mongrels appear. Interbreeding between various forms, even though they differ widely in color, results in reversion to the original type, which was a spotted or striped greenish bird, certain proof of the common origin of all.

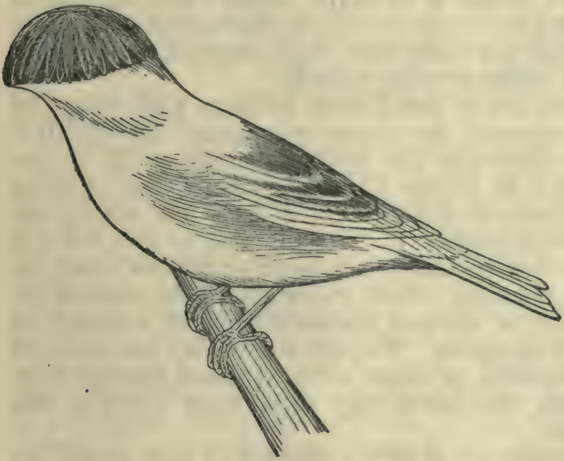

FIG. 5.—Crested canary.

CAGES.

When choosing cages in which to keep canaries, the primary consideration should be the comfort of the birds, and this should not be sacrificed to any desire for ornate appearance. There are several types on the market, any of which may serve. So far as shape is concerned, a square cage is best, as it affords more room for exercise than one that is round.

For one bird, the cage should not be less than 9½ inches long, 6½ inches wide, and 9 inches high. A larger size is to be preferred. The ordinary cages obtained from dealers in this country are made of wire and are open on all sides. Each is fitted with receptacles for food and water, usually at opposite ends. A fine-mesh wire screen may be bought from the dealer and fastened around the lower half of the cage to prevent the scattering of seeds and seed hulls. A common substitute for this is a simple muslin bag, held in place by a drawstring fastening tightly about the middle of the cage.

In a cage of ordinary size three perches are sufficient. One may be placed at either end at a distance that will allow easy access to the food and water receptacles, and the third elevated above the middle of the cage at its center. Another convenient arrangement is to run one perch lengthwise of the cage, in such way that the bird may reach the feeding receptacles from it, and to place the two other perches transversely above it near either end. A bird confined in small quarters is dependent for exercise on hopping about from perch to perch, and this arrangement will give the maximum freedom of movement. In larger cages four perches may be advisable. These should not be placed so that they interfere with the free movement of the bird, and for reasons of cleanliness one perch should not be directly above another. In small wire cages, if the swing perch usually found suspended in the center is removed, the bird will have more room, and in hopping back and forth will not be continually striking head or wings. In larger cages this perch may remain. Perches should be large enough for the toes of the bird to grasp them readily and encircle them for three-fourths of their circumference. If they are too small they cramp the foot, while if too large they may cause malformed toes or claws, especially in young birds. Perches should be elliptical in shape, about three-eighths of an inch in the long diameter, which should be horizontal. If those furnished with the cage do not meet these requirements, others may be made from soft wood without much trouble.

Cages in which canaries are to breed must be large and roomy in comparison with those intended for single occupants. An English authority gives the standard size for breeding cages as 22 inches long, 12 inches wide, and 16 inches high. Several types of open breeding cages made of wire may be obtained, or a box with a removable wire front may be made. If it is planned to use wooden cages for several seasons they should be enameled or whitewashed inside to permit thorough cleaning. Such cages should be smooth inside and any with cracked or warped boards should be avoided, as crevices may harbor dirt or mites. Though cages may be made of wire screen this is not advised, as cages so constructed become very dirty, and there is danger that birds may catch their claws in the wire and become injured.

Where numbers of canaries are kept box cages with wire fronts are convenient, as they may be placed in racks one above another or arranged on a series of shelves along the wall of the bird room. They are provided with a sand tray three-fourths of an inch deep that slides in and out from the front and facilitates cleaning. Perches for these cages may be adjusted in the following manner: One end is notched and the other has a brad driven in it filed to a sharp point. The sharpened brad is pressed against the back of the cage and a wire on the front is slipped into the notch. If made the right length the pressure of the wire will hold the perch in position.

For shipping birds the small wicker cages in which canaries come to dealers are best. These are fitted with deep, narrow-necked food and water receptacles that do not readily spill, so that there is a minimum of waste during the journey. A small packet or sack of seed should be tied to the outside of the cage in order that the bird's supply may be replenished en route.

CARE OF CAGES.

Though canaries when acclimated can endure a great degree of cold without discomfort, they are susceptible to sudden changes in temperature, and cold drafts may soon prove fatal. This should be borne in mind in choosing a place for the cage. Direct exposure to a strong draft of cold air must always be avoided. A cage may be placed on a small shelf along the wall or suspended from a bracket attached to the wall or window casing. Swinging brackets are inexpensive and are convenient for use when it is impracticable to fasten hooks in the ceiling. When one or two canaries are kept as pets, it is usual to suspend their cages before a window, where the birds may enjoy light and sunshine, a good practice where the window is kept closed during cool or stormy weather and the joints are tight. It may be necessary to line the edges of the window frame and the junction of the upper and lower halves of the window with weather stripping to prevent drafts, and it is best to suspend the cage so that it will hang opposite or below the junction of the two halves of the window frame. The room must remain at a fairly even temperature day and night, and in cold weather it is well to cover the cage with a towel or other light cloth at night. A cage should never be suspended directly above a radiator, and it is best to avoid keeping birds in small kitchens, as the fluctuations in heat are perhaps more marked there than in any other part of the house. Exposure to damp air may prove fatal, another reason for avoiding the steam-laden air of small kitchens.

Wherever placed, the cage must be kept scrupulously clean if the canary is to remain in good health and free from vermin. The supply of water should be renewed daily, and the seed cup replenished at least every other day. The receptacles for these necessities should be cleaned and washed carefully at short intervals. Cages that have removable bases should have the tray in the bottom covered with several thicknesses of paper, or the heavy coarse-grained sandpaper, known as gravel paper, that may be secured from dealers in cage-bird supplies, may be used. This should be renewed whenever the cage is cleaned, and in addition the pan should be washed in hot water from time to time. Lime on the perches may be removed by means of a scraper made of a bit of tin fastened to a wire or tacked at right angles to a stick small enough to pass easily between the wires of the cage. Cages with bottom attached should be provided with a sand tray that slides in and out through a slot in the front. This serves to catch droppings, seed hulls, and other waste, and may be easily pulled out, cleaned, and refilled with fresh sand.

INDOOR AND OUTDOOR AVIARIES.

Those who keep birds for pleasure, and who do not care to breed them for exhibition or to maintain any particular standard, may receive much enjoyment from aviaries in which numbers of canaries are kept in one inclosure. The size of the aviary or bird room will be governed wholly by circumstances, as it may range from an entire room to a small screened inclosure or part of a conservatory. A room large enough for the owner to enter without unduly frightening the occupants makes an ideal indoor aviary, and where space permits it may be fitted up without great expense. The floor should be covered to the depth of half an inch to an inch with clean sand or sawdust. Small evergreen trees planted in large pots furnish suitable decorations, and may be replaced from time to time as they are destroyed by the inmates of the aviary. A branching dead tree and one or two limbs nailed across corners at suitable heights furnish more artistic perches than straight rods. In addition, pegs 4 or 5 inches long may be driven or nailed to the walls to furnish resting places.

Seed should be supplied in self-regulating hoppers, preferably attached to the wall, and water given in self-feeding fountain containers. These become less dirty than open dishes placed on the floor. Sand must be furnished in a box or dish where it is not used on the floor. Soft foods and green foods may be supplied on little shelves or a small table. · At the proper season nesting boxes may be hung on the walls, and nesting material supplied in racks or in open-mesh bags hung to some support. A shallow pan of water may be kept constantly on the floor or, better, may be inserted for an hour each day for bathing. A screened flying cage may be built on the outside of a window and the birds admitted to it in pleasant weather. Perches, if of natural wood, should have smooth bark or should be peeled, as crevices often harbor mites. Plants and other decorations should not be placed so near the wall that birds may be trapped behind them.

Aviaries constructed out of doors, like bird rooms, may be made simple or elaborate, large or small, according to circumstances. Where there is sufficient ground available a small frame structure may be built and covered with strong galvanized wire screen of small-sized mesh. Part, at least, of the roof should be covered as a protection against stormy weather, and two sides should be boarded up to afford protection from cold winds. Where the winter climate is severe it is necessary to build a closed addition with board or cement floor and a connecting door, in which the birds may be protected during the cold season. Canaries when acclimatized, however, can withstand moderately cold weather as well as native birds.

The open portion of the aviary should have a board or cement base sunk to a depth of 8 to 10 inches around the bottom to prevent entrance of rats, mice, or larger animals. If a fence with an overhang at the top is not constructed to keep out animals, it is best to make the screen walls double by nailing screen wire to both sides of the wooden frame, so that birds clinging to the wire may not be injured by cats or dogs. Where space does not permit an elaborate structure a lean-to may be built against another wall to make an inclosure large enough for a number of birds. Where needed, the sides of the aviary may be fitted with windows that can be put in place in winter. The entrance to the outdoor aviary should be through a small porch or anteroom that need be merely large enough to permit entrance through an outside door, with a second door leading into the aviary itself. The outside door should be closed before the inner one is opened, so that none of the birds can escape.

The fittings of the outdoor aviary may be adapted from those described for the indoor bird room. With an earth floor it is possible to grow evergreen and deciduous shrubs for shelter and ornament. Where space permits a hedge of privet along the open side of the aviary furnishes a shelter in which birds delight to nest. To avoid overheating in hot weather shade should be provided for part of the structure.

In aviaries birds pair more or less at random. To avoid constant bickering or even serious fighting in the breeding season it is usual to regulate the number of males so that the females outnumber them two to one.

FOOD.

The food requirements of canaries are simple. Canary seed to which have been added rape seed and a little hemp is a staple diet that persons who keep only a few birds usually purchase ready mixed. Canary seed alone does not furnish a balanced food, but forms a good combination with hemp and summer rape. Much of the rape seed in prepared seed sold in cartons is of a species that even wild birds do not eat, as it is pungent and bitter in flavor, but all relish the mild taste of true summer rape. Seed is given in little cups that are fastened between the wires of the cage.

In addition to a seed supply lettuce or a bit of apple should be placed between the wires of the cage frequently. And those properly situated may, in season, vary this menu by the addition of chickweed, dandelion heads, thistle and plantain seeds, and the fruiting heads and tender leaves of senecio and shepherd's purse. Watercress, wild oats, knot grass, and other grasses are relished, especially in spring and early in summer.

Bread moistened in scalded milk, given cold at intervals, is beneficial. Soft foods must not be made too wet. With bread, enough liquid to soften the food but not to run or render it a paste is sufficient. Supplies of moist foods must be kept strictly fresh and clean or sickness may result. Special dishes, known as food holders, or slides that slip through the wires of the cage are often used in giving softened bread and similar supplies. Cuttle bone should always be available.

When canaries do not seem to thrive it is well to crack open a few of the seeds to make certain that empty husks alone are not being fed. Hemp, while a valuable addition to the diet, should not be given in excess, as it is fattening and may make birds so lethargic that they cease to sing, or in exceptional cases may even cause death. When canaries cease to sing from the effects of overfeeding it is well to supply some of the stimulating foods known as song restorers, or other prepared foods that may be obtained from dealers.

During the time of molt a few linseeds added to the seed supply are believed to give gloss and sheen to the new feathers. Linseeds should be given in small quantity, as they are injurious if eaten in excess. Meal worms fed occasionally are beneficial for birds that are not thriving. A craving for animal food may be satisfied by bits of raw steak, but it is not well to continue feeding raw meat for any length of time, as it may cause a foul odor about the cage. Delicate birds may be fed canary, rape, and hemp seed soaked in cold water for 24 hours, rinsed, and then drained. Maw seed (poppy seed) is favored by English canary fanciers as a stimulant, but its use must be guarded, as it may be poisonous to other animals, including man.

During the breeding season egg food must be given daily as soon as the birds are paired. This is prepared by mincing an entire hard-boiled egg or passing it through a sieve, and adding to it an equal quantity of bread or unsalted cracker crumbs. This may be given to unmated birds as well at intervals of a week or so. When female canaries begin to incubate, egg food may be fed every three or four days or even less frequently. Addition of brown sugar in small quantity to the egg food is supposed to prevent egg-binding in young females. When the young hatch, egg food should be supplied at once. Some recommend that the yolk of a hard-boiled egg be given alone for the first day. Bread crumbs are added to this daily until on the third day egg food as ordinarily prepared is supplied. Attempt should be made to regulate the supply of egg food or other soft food so that it will be eaten without waste. The actual quantity will vary in individual cases. The usual seed supply should be present, no matter what other food is given. Egg food must be given until the young are fully grown and able to crack seed for themselves. Cracked seed may be fed to lighten the labor of the parents, but it is well to eliminate hemp from such a supply, as the hull of hemp seed contains a poisonous substance that occasionally kills young birds. Drinking water should be available to canaries at all times.

BATHING.

Under normal conditions most birds probably bathe daily, and canaries in captivity should be allowed the same opportunity. In open wire cages in common use for singing birds the base is removed and the cage placed over a small dish containing water. In open-front cages in which the bottom is not detachable small bath cages which fasten at the open door are used. These are only a few inches wide but serve to hold a dish for water. Many birds are notional in bathing and at times ignore the offered bath. Usually the process of cleaning the cage and renewing the seed and water will excite in them a desire for bathing, and often when a bath is not provided the bird will do its best to perform its ablutions in the small supply of water in the drinking cup. When individual birds obstinately refuse to enter the water, if enough clean sand to cover the bottom is placed in the dish they bathe more readily. After the bath the water may be drained carefully and the sand left to dry in the dish for use another time.

Birds brought into strange quarters may refuse to bathe for the first few days. When water is offered they either ignore it or sitting on a perch go through the motions of bathing and drying, fluttering wings and tail with a great whirring of feathers. The bath should be offered whenever the cage is cleaned, and if left alone the birds will act normally after a few days.

Small china or earthenware dishes that are not too deep make good bathing pans. When a bird becomes accustomed to one dish it will usually refuse to bathe in another of different shape or color. In winter the water should be warmed until tepid. Even in warm weather very cold water is not advisable. If the room, ordinarily warm, becomes cold temporarily, birds should not be allowed to bathe. With the plumage wet and bedraggled there is increased susceptibility to cold drafts. During molt the bath should be given not more than twice each week. If the bird is molting on color food, one bath each week is sufficient. The female canary should not be allowed to bathe from the time the eggs hatch until the young are 3 or 4 days old.

MOLT.

Canaries renew their covering of feathers once each year. In adults this molt occurs late in summer, and the first sign of it may be the presence of a wing or tail feather on the bottom of the cage. These large feathers are shed in pairs, so that one from either wing or from either side of the tail is dropped at approximately the same time. Never in ordinary circumstances does the canary have the wing and tail entirely devoid of large feathers. This provision is of no particular significance in a cage bird, but enables wild birds to maintain their powers of flight. The bodily covering is renewed piecemeal as well, so that except about the head there is normally no extensive area wholly devoid of feathers at any time. Some birds drop a few of the body feathers all through the year, a symptom that need cause no anxiety.

With breeding birds the molt usually comes immediately after the breeding season and may begin as early as the latter part of July. Normally it comes during August, and on the average should be at its height in September. Young birds molt the juvenal body plumage after leaving the nest, but retain the first growth of wing and tail feathers for a year. In healthy birds the entire molt requires about two months.

Canaries usually need no special care during molt. Though in an abnormal bodily state at this time, healthy individuals will come through the period in good condition. Birds are somewhat dull and stupid when molting and should be disturbed as little as possible. Bathing may be permitted once or twice each week, but if birds do not wish to bathe they should not be sprayed with water. It is well to add egg food or moistened bread to the ordinary fare once or twice each week during molt. For ailing birds a very slight quantity of sulphur may be added to the egg food, or a weak saffron tea given instead of pure drinking water. A few linseeds in the seed supply give a gloss and sheen to the new feathers not otherwise obtainable.

When canaries fail to molt at the proper season molt may sometimes be induced by covering the cage with a dark cloth and placing it in a warm protected place where the bird will not be disturbed.

Old birds or those weak in physical vigor often fail to renew their entire feather covering, a condition for which little remedy may be offered. Usually this incomplete molt is a sign of extreme age or breakdown, though if the bird lives, a supply of nutritious, easily assimilated food and careful protection during the next molt may result in improvement.

A great change in temperature or a sudden chill may check the progress of molt and occasionally cause serious trouble. If a bird shows signs of distress, it should be placed at once in a warm, protected place. Ten drops of sweet spirits of niter and a few shreds of saffron added to the drinking water are beneficial.

COLOR FEEDING.

That the color of canaries may be deepened or intensified by certain foods given during the molt is well known and has attracted much interest. Turmeric, marigold flowers, saffron, cochineal, annatto, mustard seed, and other agents rich in natural color are often used for this purpose, ordinarily in combination with red pepper as a base. For a long time methods of preparing and feeding color foods were kept secret, but now they are outlined in many manuals on canary feeding.

In selecting canaries for experiments in color feeding preference should be given to strong, vigorous, male birds. During digestion and assimilation the concentrated food used puts more or less of a strain upon the system, and birds that are old or constitutionally weak may not thrive, or may even succumb under the treatment. Color food may be given young canaries at the age of 7 or 8 weeks to produce a deep color at their first molt. Birds with color that is naturally full and rich should be selected. Those having greenish markings or those descended from a male parent well marked with green are preferable. Pale birds seldom color well.

A standard color food may be prepared as follows: To the ordinary egg food (one hard-boiled egg chopped fine with an equal bulk of bread crumbs or unsalted cracker crumbs) add a teaspoonful of ground sweet red pepper. Mix until the food shows an even reddish tint throughout. Care should be taken to see that the supply of ground sweet pepper used is fresh and clean and that it is not artificially colored. Each bird to be experimented upon should receive one small teaspoonful of the prepared food daily. The quantity of pepper in the mixture is increased gradually, until two heaping teaspoonfuls are used. Addition of a little brown sugar and a few drops of pure olive oil is beneficial, and a small quantity of hot red pepper gives a better flavor. The food should be prepared fresh each day, and in mixing allowance must be made for variation in the size of eggs used.

Some breeders increase the proportion of sweet red pepper until 4 teaspoonfuls are added to the usual quantity of egg food. Half a teaspoonful of this concentrated food is allowed each bird. This method may be used during a short, quick molt. The usual supply of seed must be kept in the cage, for canaries can not subsist on the color food alone.

Those who do not care to use such an elaborate preparation in color feeding may substitute pieces of the common sweet red peppers sold in fresh vegetable markets for the bits of lettuce ordinarily given as green food. Canaries eat these readily, and from the effect of this food eaten during molt become noticeably deeper and richer in color.

Color feeding to be successful must be started as soon as the canaries are ready to molt, and feeding must be continued until no more pin feathers can be found anywhere on the body when the feathers are carefully blown aside. The color food actually supplies an enriched color element that otherwise is lacking. Until the artificial color is firmly fixed in the matured feather it fades easily when exposed to strong light. The birds chosen for color feeding should be kept in a dim light away from the windows and with the cages shaded. Open-front cages are easily provided with a screen of paper or cloth, but care must be taken to leave space for ventilation. Direct sunlight must be avoided. Bathing must not be permitted more often than once a week, and the birds should be disturbed as little as possible.

Should a bird refuse the color food, the seed supply may be removed for a short time morning and evening and the color food substituted. Usually in a day or two the stimulating food will be eaten eagerly. Linseeds should be given (as during the regular molt) to impart a gloss to the new feathers. With proper care there will be little trouble in producing fine, healthy birds with rich, highly colored plumage. The enhanced color lasts only during the continuance of the growth of feathers, and if color feeding is not resorted to at the next molt the canary will again be plain.

BREEDING.

The breeding season for canaries begins properly in March. Though birds often show signs of its approach as early as January, it is better, because of the effect of changing weather conditions upon callow young, to postpone nesting activities until later, if possible. Some canary fanciers keep canaries paired throughout the year, but the more common practice is to separate the sexes except when breeding. The beginning of the mating season is marked by ringing, vigorous song among male birds, accompanied by much restless activity. Females, indifferent until now, respond with loud call notes, flit their wings, and otherwise evince their interest. Birds may be paired without these preliminary signs, but usually this tends only to lengthen the breeding season without material benefit. The instinct to breed may be stimulated when necessary by the addition of egg food and green stuff to the diet.

Canaries in captivity are polygamous when opportunity offers, and many breeders place two or even three females with each male. Others, however, keep canaries in pairs, as they are more readily handled, and when the young are hatched the male is able to assist in caring for them. Where two females are kept with one male the birds should be placed in a cage divided by slides into three compartments. The male is placed in the middle, and a female on either side. During half the day the male is thrown with one female and during the remainder with the other. This arrangement necessitates the use of three sets of seed and water cups in each cage. When the females begin to incubate the male is removed or excluded from both.

A cage suitable for one pair of canaries should be equipped with a sliding wire partition. The male and the female are placed one in either compartment and the two left to make acquaintance. The male will begin to feed the female through the wires in a day or two, or perhaps at once, and when this is observed the slide may be withdrawn and the birds kept together. If a cage is used that has no slide, there is usually some bickering between the birds at first, but birds are rarely found that do not in the end agree. A cage thus used without a slide should be new to both birds, in order that neither may resent the presence of an intruder in a cage which it has been accustomed to consider its own.

Soon after pairing the female will be seen carrying feathers in her bill or searching about the bottom of the cage. If a little nesting material is given her she will be content to arrange and rearrange it for a few days. As soon as she shows serious intention of building, enough material for actual nest construction may be supplied. If a considerable quantity is furnished at first it is merely wasted. The material may be held in a small wire rack suspended on the outside of the cage or placed inside. Bits of string, cotton, slender blades of dried grass, dried moss, cow's hair, or other soft material will serve well. No long strings or long hairs should be given, as these may cause trouble later by entangling the feet and legs of mother and young. Everything furnished should be clean and free from dust. Some canaries are expert nest builders, while others construct a slovenly structure that barely serves to contain the eggs. Some fanciers prefer to construct nests for their birds, and with certain birds this is necessary as some females may refuse to build.

Canaries build in anything that offers support. A nest box of wood, or, better, an earthenware nest pan, may be fastened to the side or back of the cage midway between the two perches. The rush or willow nests sold by many dealers, while serviceable, may harbor vermin. The earthenware nest pan is best, as when the breeding season is over it is readily cleaned and put away for another year. Failing this, a box 1¼ inches or more deep made of thin wood may be used. The nest box or pan should have a lining or bottom covering of felt. This may be pasted in the earthenware pan, and may be soaked loose without trouble when it is desired to renew it. The nest receptacle, of whatever description, should be suspended an inch above the level of the perches. This prevents the young from leaving the nest too soon. The receptacle should not be near enough to the top of the cage to interfere with the movements of the occupants. If the nest is not too near the perches the male is not so likely to be obtrusive during incubation.

The first egg will be deposited from a week to a month after the birds are paired. Normally it is laid in about two weeks. The number of eggs in a sitting may vary from three to six, with four or five as the usual number. The eggs should be removed as soon as laid. This may be done readily with a teaspoon, with care not to injure the delicate shells. They should be kept in a cool place, slightly embedded in fine corn meal or bran or cared for in some other manner that does not allow them to roll about or touch each other. On the evening of the day on which the third egg is laid all may be returned to the nest.

Removing the eggs and then replacing them postpones incubation and development in those first laid and makes the time of hatching more even. The normal period of incubation is 14 days.

Egg binding sometimes causes trouble and may be dealt with as follows: The vent may be oiled carefully with a drop or two of warmed castor oil and the bird returned to the cage. If the egg is not deposited within half an hour the canary should be held for a few minutes with the vent over the steam of hot water. A good method is to fill a narrow-necked jar or bottle with hot water and cover the mouth of the receptacle with cheese cloth; the female is then held carefully for a minute or two in the rising steam. Often the egg will drop at once and be caught in the cheesecloth, or it may be deposited in the normal manner after the bird is returned to the cage.

The male canary is ordinarily a model husband and parent, giving no trouble, but if he should annoy the female during incubation or attempt to injure the young he should be removed at once. It is the natural instinct of an incubating bird to conceal itself as much as possible, and though canaries are tame, this tendency should be recognized and respected. This does not mean that they are to be neglected. Each breeding cage should be equipped with a sand tray which should be cleaned at least every other day. In no other way can it be hoped to rear numbers of birds successfully. Except for this necessary care and the provision of food, water, and bathing facilities, the birds should be bothered as little as possible.

Sometimes trouble is caused by inability of the young to free themselves from the shell or egg membrane, a condition for which there is usually no remedy at the time. With succeeding settings the difficulty may be obviated by sprinkling the eggs slightly with water each evening. Some breeders when the young canaries are 8 days old place them in a new nest, a practice that may be necessary when the old nest is infested with parasites. In such instances a little insect powder should be sprinkled over the body before the young birds are placed in their new quarters.

The young birds leave the nest when 20 to 30 days old. They may be left with the parents as long as they are fed and should never be removed entirely until it is found that they are able to crack the seeds upon which they must feed. It is advisable to continue the use of egg food for a time and gradually to decrease the amount given to get the birds accustomed to a diet of seed alone.

Canaries often rear two or three broods a season and the female may be ready to breed again when the young are three weeks old. It is only necessary to provide a second nest and nesting material and let her proceed. The care of the young will then devolve on the male. Nesting material should be provided at once or the female may pluck the feathers from her growing young. If this can not be stopped the young should be placed in a small nursery cage suspended from the side of the breeding cage in a manner that will allow feeding between the wires. When the young are finally removed they must not be placed with birds older and stronger for a time. They should be watched carefully the first day, and if any one does not feed it must be returned to the parents at once. Though most of the losses among canaries come at this time, with care in food and cleanliness there should be little trouble.

SEX AND AGE.

To determine sex and age in living canaries is difficult and is to be attempted only by one who has had long experience as a canary fancier. The external characters denoting sex are not easily described. In nearly all cases a male may be recognized by his proficiency as a songster, but occasionally female birds also possess a clear, full song. When in breeding condition the sex may be determined readily by examining the vent. In males it is protuberant, while in females it does not project below the level of the abdomen. By daily observation the canary breeder is generally able to distinguish the sexes through slight differences in carriage and mannerisms not apparent to one not familiar with them.

In judging age the feet offer the only characters easily seen, but even these can not always be relied upon. Birds a year old or less usually have the skin and scales covering the feet and tarsi smooth and of fine texture. In older birds they appear coarser and roughened. Very old birds usually have had the claws trimmed until they appear blunt or rounded rather than sharp and pointed (see p. 19).

Canaries have lived many years when cared for regularly. Dr. C. W. Richmond, Associate Curator of Birds in the United States National Museum, relates that two birds, hatched in the same brood and kept entirely separated after they left the nest, lived 18 years, dying within a few weeks of each other. Another case is on record in which a canary was known to be at least 34 years old when it died, and even this advanced age may have been exceeded. Usually with advancing years birds molt irregularly or lose part of the feathers entirely. Often their eyesight is impaired. It is said that canaries that have not been paired live much longer than those allowed to breed.

VERMIN.

Canaries are affected by two forms of external parasites. The larger of these, a bird louse[2] known usually as the gray louse, is an insect with a slender, elongate body and a large head armed with strong jaws. This pest feeds upon the feather structure of the bird's outer covering, and though it does not suck the blood of its host, its sharp claws irritate the skin and cause discomfort to the bird. The eggs of the gray louse are attached to the feathers by a gum and are not easily removed. The young insects resemble the adults and in a few weeks after hatching are fully grown. They are best combated by blowing insect powder (pyrethrum) into the plumage of the affected bird with a small bellows or blower. This treatment should be repeated two or three times at intervals of a week to insure the destruction of any young lice hatching in the meantime.

The other parasite of canaries is a small mite,[3] a minute spiderlike creature that when fully grown is barely visible to the unaided eye. Its natural color is whitish, but nearly always it is filled with blood sucked from the body of the unfortunate bird harboring it, so that it appears bright red. These mites are nocturnal, and except in cases of severe infestation are seldom found upon the body of their host during the day. They are often found in the slits at the ends of the perches or in the round piece of metal forming the support at the top of the ordinary wire cage. In wooden cages they hide in cracks, nail holes, or crevices, and their presence is betrayed upon close examination by minute white spottings. If unnoticed, they multiply rapidly and sap the strength of the bird by sucking its blood. When their presence is suspected a little coal oil, or kerosene, applied freely to the cage with a brush may be sufficient to kill the pests. Or the bird may be removed temporarily and the cage cleaned thoroughly with a solution of 1 ounce of commercial carbolic acid in a gallon of water, applied with a small brush, taking care to reach all crevices. In severe infestations it may be necessary to immerse the cage for several minutes in water that is boiling hot. Insect powder may be used as for the gray louse.

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[2] *Docophorus communis* Nitzsch. Order Mallophaga.

[3] *Dermanyssus avium* De Geer, closely allied to the chicken mite *D. gallinae* De Geer.

Where facilities for frequent bathing are offered and the cage is kept clean, there is usually little trouble with either mites or bird lice. When a bird is sick and neglects its customary bathing, cleaning, and preening, it is surprising to see how rapidly these pests multiply. With care, however, they may be completely eradicated, though fresh outbreaks are likely to occur when new birds are obtained. In wooden cages cracks in the boards that have harbored mites may be closed with glue to prevent a return of the pests.

CARE OF FEET AND BILL.

As a canary grows old it will be noticed that its claws become long and catch on the perches and wires as it hops about the cage. In a state of nature the activities of the bird as it moves about on the ground or among twigs and limbs keep the claws properly worn down. Confined in a cage, the canary is less active, and while the claws have the same rate of growth they are here subject to much less abrasion. It is necessary, therefore, to trim them with a pair of sharp scissors every few months. It is important to watch the condition of the claws carefully, as by catching they may cause a broken leg. In each claw a slender blood vessel extends well down toward the tip. This is indicated in Figure 6 by the letter *A*, and may be seen on close examination through the transparent sheath of the bird's claw. In trimming cut well beyond this canal (at the point *B* in the figure) and take special care not to break the leg while handling the bird.

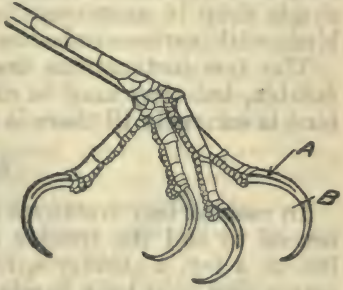

FIG. 6.—Diagram of foot of canary with overgrown claws. *A*, Terminal blood vessel; *B*, point at which claw may be trimmed without injury.

In cage birds the horny covering of the bill, as well as the claws, sometimes becomes distorted through growth without sufficient wear. The tips of the mandibles may be pared down with a sharp knife, but care must be taken not to cut deep enough to reach the quick.

DISEASES AND INJURIES.

With ordinary care in cleanliness, freedom from cold damp drafts, and a well-regulated food supply, canaries are subject to few ills. In fact, most of their troubles may be traced to some untoward circumstance in handling them. Their diseases are very little understood and correct diagnosis is difficult, and though much has been written regarding them this has served mainly to reveal general ignorance on the subject. Present knowledge does not warrant an exhaustive account of diseases, but in the following notes information is given on the more usual complaints of canaries.

When canaries become sick the first care should be to see that the diet is proper and to examine into the general sanitary conditions under which the birds are living. If canaries are confined in company with others, sick birds must be removed at once to a separate cage, since their companions will continually peck and worry them. Where numbers of canaries are kept, as a precaution to prevent spread of contagious or infectious diseases ailing birds should be removed from the bird room. It is always well to move a sick bird to a warm place. Heat and protection from drafts work wonders with ailing canaries and often are sufficient alone to restore them to health.

When medicine is necessary it is best to administer it in the drinking water. If this can not be done it may be given directly in the bill by means of a quill or a medicine dropper. In administering medicines it must be remembered that a canary is small and that a single drop in most cases is a large dose. Indiscriminate dosing of birds with various remedies is to be avoided.

The few instructions that follow are not to be regarded as infallible, but they may be of assistance in simple ailments. When a bird is seriously ill there is usually little chance of its recovery.

BROKEN LIMBS.

In case of bad fractures or injuries it is perhaps best for all concerned to end the trouble by killing the bird. If a valuable bird breaks a leg, a slender splint of wood wrapped in a slight wisp of cotton and held by a bandage may be applied with care. This support must not be touched for two or three weeks, but then it may be removed entirely. When the break occurs in the lower leg (tarsus) a small quill makes a simple support. The quill is split and cut down until it fits snugly around the part affected. It is then padded inside with a few shreds of cotton and tied carefully in place with silk thread.

Broken wings should be allowed to heal without outside interference. All high perches should be removed from the cage, and food and water made easily accessible. A bird with a broken wing must be kept as quiet as possible in order that the fracture may heal.

LOSS OF FEATHERS ABOUT HEAD.

Baldness is sometimes occasioned by mites or bird lice and may be treated best by removing the cause. Loss of feathers about the head, however, may indicate old age or general debility. At the natural time of molt the growth of feathers on the bare spots may be aided by warmth and a well-regulated diet. In addition to the usual food, twice a week give a little bread moistened with milk which has been dusted with a mixture of two parts of sulphur to one of potassium chlorate. At the same intervals rub a little carbolized petrolatum on the bare places. Baldness is said to arise at times, particularly in spring, through failure to provide the canary with lettuce, apple, or other green food. In such cases improvement may be made by supplying this need.

RESPIRATORY TROUBLES.

The fact that canaries are injured by cold drafts can not be too strongly emphasized, and it may be said that a large proportion of their common ailments come from such exposure. In many cases exposure is followed by congestion in the intestinal region, and death ensues in a very short time. In ordinary colds there is difficulty in breathing and some liquid discharge from the nose. Frequently this is accompanied by coughing. A bird thus affected should be kept in a warm room free from all drafts and protected from irritating dust, vapor, or tobacco smoke. The symptoms are increased as the cold progresses and becomes acute, and the bird sits with feathers puffed out, seeming really ill. Breathing is difficult and rapid. If there is enough catarrhal secretion partly to block the respiratory passages a slight bluish tint is noticed beneath the transparent sheath of the bill. As a remedy, place in the drinking cup 1 ounce of water to which have been added 20 drops of sirup of tolu, 10 of sweet spirits of niter, and 10 of glycerin.

Pneumonia in cage birds often follows exposure and is nearly always fatal. The symptoms, rapid and difficult breathing with little catarrhal discharge, appear suddenly. The bird becomes very weak at once and usually dies in from two to seven days. Little can be done beyond sheltering the bird, as noted above, and providing an easily assimilated food, as egg food and bread moistened in milk.

Asthma is a chronic affection, in which there is difficulty in expiration of air in breathing. In severe cases a contraction of the abdominal muscles is evident in forcing the air from the lungs. Asthma is more in evidence at night, and often birds apparently free from it during the day will wheeze when at rest. There is practically nothing that can be done for it. Sometimes a semblance of asthma is caused by indigestion from overeating. Fanciers consider asthma hereditary and do not recommend birds so affected for breeding purposes.

INTESTINAL COMPLAINTS.

Intestinal troubles in canaries arise in most cases from the food or water supply and are avoided by cleanliness and proper care. Dirty water cups with foul water, decayed or soured fresh or soft foods, or a poor seed supply lead inevitably to trouble. Should the canary contract diarrhea, remove all green and soft foods from the cage for a time and give only the normal seed supply. As a remedy, add a small quantity of Epsom salts to the drinking water for a day. If there is no improvement, feed the bird a bit of moist bread, with the surface covered lightly with bismuth (subnitrate), or place an ounce of water in the drinking cup, to which have been added three or four drops of tincture of opium. For constipation, the addition of lettuce, apple, chickweed, or other green food to the regular menu is usually sufficient; if not, a pinch of Epsom salts may be added to the drinking water. The quantity of the purgative should be enough to impart a faintly saline taste to the solution. Castor oil is not a good corrective remedy for small birds.

Occasionally birds in confinement "go light," or waste away until they are far below their normal standard of plumpness, without marked symptoms of disease. In such cases change the seed supply, making sure that the seed is fresh and wholesome, and vary the diet with green foods, and with bread softened with milk. It is also beneficial to change the location of the cage; if possible, place the cage where it will receive the sun for a few hours each day, except in the heat of midsummer. Make sure that the canary is not infested with mites.

When worms are present, as sometimes happens, small fragments of these internal parasites may be seen in the droppings when the cage is cleaned. As a remedy, place in the drinking cup 8 or 10 drops of tincture of gentian in an ounce of water. This may be given for two days, and, in addition, two drops of olive oil may be administered in the bill by means of a medicine dropper.

For more serious complaints than those enumerated it will be well, if possible, for the amateur to seek the advice of some person with experience in handling cage birds.

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U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1328

PRODUCTION OF SEED FLAX

1862 1889

SEED FLAX is grown chiefly in North Dakota, Minnesota, South Dakota, and Montana. Since 1909 the production of flaxseed in the United States has not equaled the requirements of our industries. The crop of 1923, estimated at 17,429,000 bushels, was less than half the quantity consumed during the fiscal year.

Until recent years seed flax has always been grown on new lands, near the frontier. With the development of wilt-resistant varieties it is now grown successfully on the older cultivated lands.

On new land in the northern Great Plains varieties of European seed flax, such as North Dakota No. 155 and North Dakota Resistant No. 52, are best adapted. Where flax wilt is present a wilt-resistant variety, such as North Dakota Resistant No. 114, should be grown. Two new varieties, Chippewa and Winona, recently distributed by the Minnesota Agricultural Experiment Station, are well adapted to growing on wilt-infested soil.

Grow flax on clean land. Flax does well following corn which has been given clean cultivation. A rotation which includes a legume crop, such as field peas, soybeans, sweet clover, or red clover, followed by corn and finally by flax, is very satisfactory.

Flax and spring wheat are grown successfully as a mixed crop in southeastern Minnesota. The advantages of the mixed crop are (1) greater ease in handling, (2) better control of weeds, and (3) a possible greater return per acre. The mixed crop provides greater crop diversification where it can be grown successfully.

Flax should be sown early as a general rule on a well-prepared, firm seed bed. It may be sown as late as the first week of June, however, provided the land has been kept free from weeds by cultivation.

The rate of seeding ranges from about 20 pounds per acre on the drier lands of the northern Great Plains to 40 pounds per acre under the humid conditions of eastern Minnesota.

Flax is harvested with a grain binder, reaper, or header. It should be threshed as soon as it is thoroughly dry.

This bulletin supersedes Farmers' Bulletin 785, Seed-Flax Production.

Washington, D. C. Issued November, 1924.

PRODUCTION OF SEED FLAX

By A. C. Dillman, *Associate Agronomist, Office of Cereal Investigations, Bureau of Plant Industry*

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INTRODUCTION

THE UNFAVORABLE WHEAT SITUATION has again focused attention on flax as a cash crop. The good yields of flax obtained in 1922 and 1923, together with the satisfactory price received by producers, has made flax more profitable generally than wheat or oats. The increased acreage of flax in 1923, moreover, has provided greater diversification of crops in the area producing seed flax.

Flaxseed is the source of linseed oil. No satisfactory substitute has yet been found for linseed oil in the manufacture of paints and varnishes. The demand for flaxseed, therefore, during the building boom of recent years has been greater than ever before. This demand is likely to continue. There are thousands of farm buildings that are in need of paint and that no doubt will be painted when greater prosperity returns to the farming industry.

It is estimated by the paint industry that approximately 80 per cent of the paint and varnish consumed is used in repainting older buildings and only about 20 per cent on new buildings and manufactured goods, including machinery and automobiles.

HISTORY

Flax, grown for fiber, was one of the first crops introduced from the Old World. In colonial times nearly every household had its patch of flax, and it continued to be grown to some extent for home use as late as 1840. It was very early in the nineteenth century that the manufacture of linseed oil was begun in this country.

Until recent years flax has been a pioneer crop in the history of American agriculture, and the center of production has always been near the frontier. The census of 1850 showed Ohio and Kentucky to be the leading flaxseed-producing States. By 1900 the center of production had shifted to North Dakota. During those 50 years the crop had migrated with the advance of settlement from Ohio across Indiana, Illinois, Iowa, and Minnesota to North Dakota. The crop evidently now has reached the western limit of its migration. For the past 20 years North Dakota, Minnesota, and South Dakota have been the chief States in the production of flaxseed.

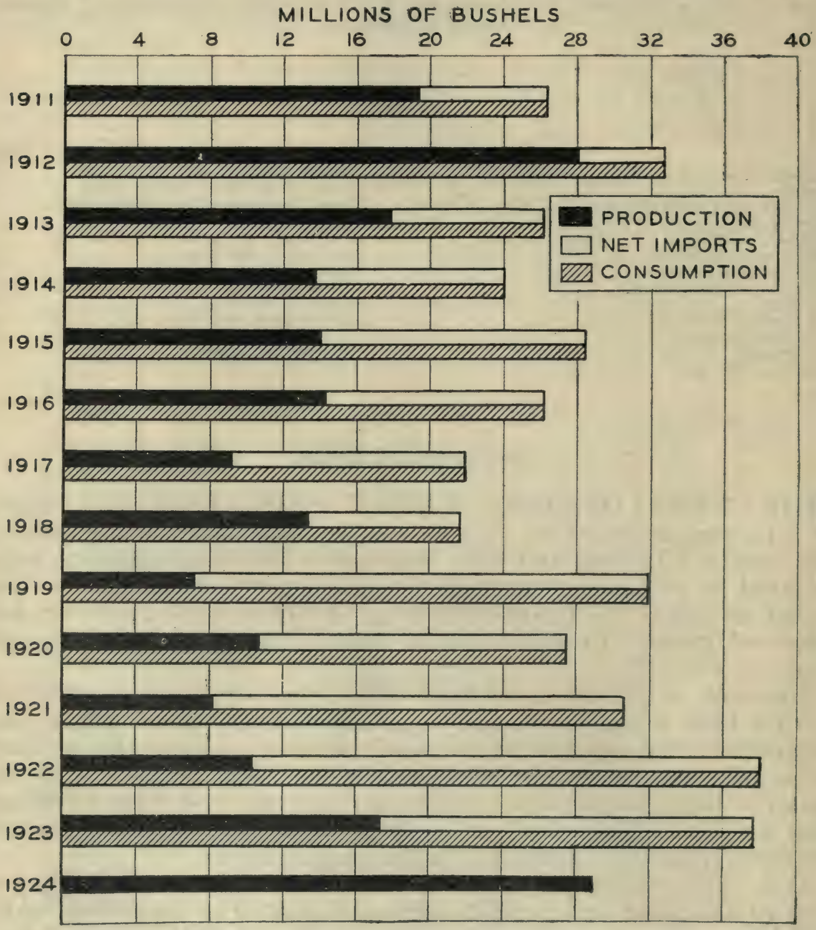

FIG. 1. Flaxseed production, net imports (including linseed oil in terms of seed), and consumption in the United States from 1911 to 1923, inclusive, with a preliminary estimate of production in 1924. The chart is based on the revised production figures published in the Yearbook of the Department of Agriculture for 1923 and on preliminary estimates for 1923 and 1924 of the Division of Crop and Livestock Estimates. (Estimated production for the calendar years specified. Estimates of net imports and consumption for the commercial years beginning July 1 of the years specified)

For 10 years previous to 1908 the United States produced a surplus of flaxseed, and considerable quantities were exported to Europe. Since 1908, however, the production of flaxseed has not been sufficient to meet the requirements of our industries, and in recent years large quantities have been imported from Argentina and Canada. The consumption, production, and net imports of flaxseed in the United States from 1911 to 1923 are shown graphically in Figure 1.

THE FLAX-GROWING AREA

Flax is grown under a wide range of soil and climatic conditions. It produces best, however, on the clay-loam soils of the North-Central States where the summer temperature is moderate and rainfall adequate. The area of flaxseed production in 1919 is shown in Figure 2. In western Minnesota, eastern North Dakota, and northeastern South Dakota, the center of the flax-producing area, the average annual rainfall varies from 20 to 30 inches. In central North Dakota and South Dakota the rainfall averages 16 or 18 inches annually and diminishes westward to about 14 inches in central Montana. In this area the crop depends largely upon the summer rainfall and yields well or poorly according to the amount.

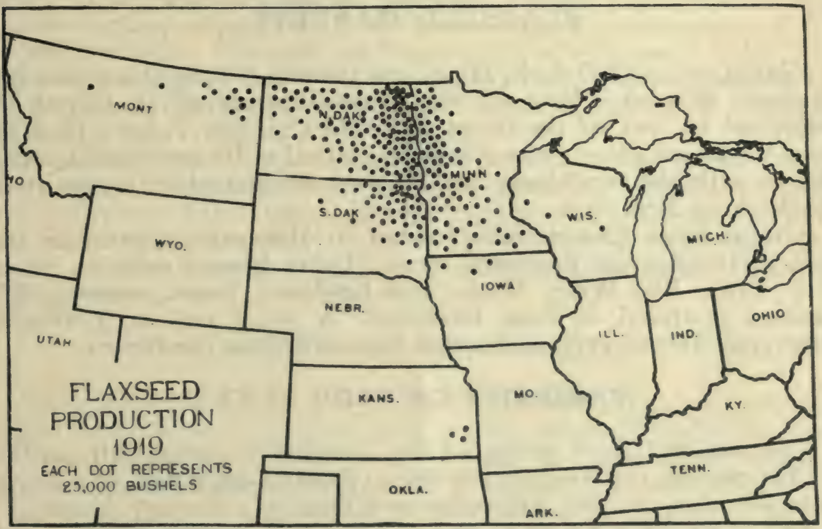

FIG. 2.—Distribution of flaxseed production in 1919, according to the census of 1920. The four States of North Dakota, Minnesota, South Dakota, and Montana produce approximately 95 per cent of all the flaxseed grown in the United States.

Under these drier conditions flax with short coarse straw and nonuniform fiber is produced. As the crop is of little value for fiber, only the highest yielding seed-flax varieties should be grown. In the principal flaxseed-producing area, where the annual rainfall is 20 or 30 inches, seed flax produces a fair quality of fiber suitable for those industries which heretofore have used imported flax tow and waste. Where the rainfall is more abundant it is possible in some localities to grow flax producing excellent fiber for spinning. The growing of flax for fiber is treated in Farmers' Bulletin No. 669, "Fiber Flax," and the use of the straw of seed flax is discussed in Department Bulletin No. 322, "Utilization of American Flax Straw in the Paper and Fiber-Board Industry." Copies of these bulletins may be obtained upon application to the United States Department of Agriculture, Washington, D. C.

USES OF FLAXSEED

Seed flax is a cash crop, very little of it being consumed on the farms where grown. The two products of flaxseed are linseed oil and linseed meal. Linseed oil is used in the manufacture of paints and varnishes, in linoleum, oilcloth, printer's ink, patent leather, imitation leather, and a few other products. The flaxseed is ground, heated, and pressed to extract the oil. The residue left after the oil is extracted is known as linseed cake or, if ground, as linseed meal. It is a valuable feed for livestock, especially for dairy cattle and young growing animals.

Flaxseed yields from 30 to 40 per cent of its weight in oil, or, in commercial crushing, about 2½ gallons (7½ pounds per gallon) to the bushel (56 pounds) of seed.

FLAXSEED MARKETS

Minneapolis and Duluth, Minn., are the two principal markets for domestic flaxseed. Most of the flaxseed marketed at Duluth is reshipped by way of the Great Lakes to Chicago, Toledo, Buffalo, New York, and other cities where linseed-oil mills are located. The eastern mills also crush large quantities of flaxseed which is imported, chiefly from Argentina.

Several large linseed mills located in Minneapolis consume the bulk of the flaxseed marketed there. Other linseed mills at Sioux City, Iowa, Red Wing, Minn., and Fredonia, Kans., consume the flaxseed produced in their localities. A small mill at Portland, Oreg., operates largely on flaxseed imported from the Orient.

VARIETIES OF SEED FLAX

Four rather distinct groups of flax are grown commercially in the United States: (1) Textile-fiber flax, (2) short-fiber flax, (3) European seed flax, and (4) Argentine seed flax.

The textile-fiber flaxes are not grown for seed, although the seed is a by-product used for crushing when they are grown for fiber. This is the only group producing fiber suitable for spinning.

In the short-fiber group are several varieties that have been developed for resistance to flax wilt. They have been derived from the fiber-flax type and have more slender stems than the so-called Russian or European seed flaxes. They have fewer basal branches, a more compact panicle (head), and generally are somewhat earlier than the seed flaxes. The bolls and seeds are smaller than those of the seed flax.

The best known variety of this group is N. D. R. No. 114, distributed by the North Dakota Agricultural Experiment Station. Recently the Minnesota Agricultural Experiment Station has developed two varieties of this type which are highly resistant to wilt. These have been named Chippewa (Minnesota No. 181) and Winona (Minnesota No. 182). Seed of both varieties is being increased and distributed.

The European flaxes have stouter stems, more basal branches, larger and more uneven panicles, and larger bolls and seeds than the short-fiber type. To this group belong the several strains of the so-called Russian flax, North Dakota No. 155. Two of the best of these are Damont (C. I.[1] No. 3) and Reserve (C. I. No. 19). To this group belong also N. D. R. Nos. 52 and 73, distributed by the North Dakota Agricultural Experiment Station. These varieties are grown principally on the newer lands in western North Dakota and Montana, where the wilt disease is not yet a serious factor in seed-flax production. These varieties as grown commercially generally are not very wilt resistant. Recently the development of wilt-resistant varieties of this group has been begun.

The Argentine flax of commerce is not well adapted to the flax-producing area of the United States. The plants are nonuniform and generally coarser than the seed flaxes. The stems, flowers, bolls, and seeds are larger than in the European seed types. There generally are basal branches which do not grow as tall as the main stem. The plants are late in maturing. If the plants are not ripe by the first of September, they often continue blossoming and fail to mature well. The bolls are large and retain the seeds well. The seeds also are large and when mature yield a high percentage of oil. If Argentine flax is grown, it should be seeded early so as to insure ripening.

Argentine flax is more or less resistant to flax wilt, and the plants are practically immune from flax rust. Because of its disease-resistant qualities and its large seeds Argentine flax is a promising type for the plant breeder to work with in developing new varieties. An early uniform variety should be a valuable asset to the flax-producing area of the United States.

VALUE OF GOOD SEED

There is a difference in the yield of varieties of flax under varying conditions. Where flax has been grown frequently and the wilt disease is present, it is necessary to use a wilt-resistant variety, such as N. D. R. No. 114 or one of the newer varieties, Winona or Chippewa, recently introduced by the Minnesota Agricultural Experiment Station. Such varieties yield well on wilt-infested soil, where ordinary flax would fail entirely. The United States Department of Agriculture and the North Dakota Agricultural Experiment Station each has developed new wilt-resistant varieties which are being tested and should soon be available for commercial growing.

On new lands in the flax-producing area, and especially in the northern Great Plains, varieties of the European seed flax, such as Damont, Reserve, N. D. R. No. 52, and some local strains are likely to produce maximum yields. These larger seeded varieties appear to have greater capacity to produce large yields under favorable conditions than the smaller seeded wilt-resistant varieties.

Where new seed must be obtained, it often is best to buy it in the locality from some one who is known to have a high-yielding strain free from weeds and disease. If such seed is not available, the State agricultural experiment station or the Bureau of Plant Industry of the United States Department of Agriculture usually can advise where desirable seed can be purchased.

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[1] Accession number given by the Office of Cereal Investigations of the Bureau of Plant Industry.

When an improved variety of flax has been obtained, it should be kept pure and free from weeds. A portion of the field that is free from disease should be chosen, and all weeds the seeds of which can not readily be separated by the fanning mill should be pulled by hand and destroyed. In this way seed flax is obtained that (1) is adapted to the locality, (2) is free from admixture with weed seed that will infest the field and reduce the yield, and (3) is relatively free from disease. It is practically impossible, however, to avoid introducing flax wilt where flax is grown on the farm continuously. When it is known that wilt is present in the soil, it is best to get seed of a wilt-resistant variety.

DISEASES OF FLAX

The principal diseases of seed flax are wilt, rust, heat canker, and pasmo.

WILT

Wilt is a fungous disease that attacks flax plants at any stage of growth, causing them to wilt and die. It grows both upon the live plant and upon the dead flax roots and stems in the soil. When once introduced, therefore, it increases in the soil for an indefinite period. Authentic cases are known where a crop of flax was grown without noticeable loss from wilt, but when flax was sown on the same land five years later it was entirely destroyed by wilt. The fungus, no doubt, was introduced into the soil in seeding the first crop and increased during the five-year period until it was widely distributed through the soil. Figure 3 shows the effect of wilt on a plat of flax in the fifth year of continuous cropping. In many cases such spots of wilt appear in the second or third crop.

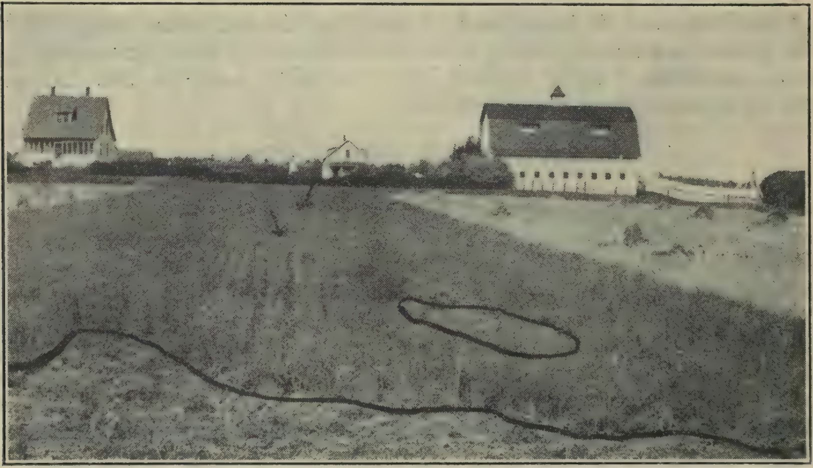

FIG. 3.—A fourth-acre plat continuously cropped to flax, showing the first appearance of flax wilt in spots. The flax is grown under irrigation on the Belle Fourche Experiment Farm, Newell, S. Dak.

In order to avoid infection of new lands with the wilt, only mature well-cleaned seed should be sown. Care should be taken in harvesting and threshing to save the seed in a dry condition. The fungus grows rapidly on wet straw, seed bolls, and seed, and therefore only dry, bright flax should be saved for seed. Treatment with formaldehyde will kill the fungous spores on the surface of the seed and may help prevent the introduction of wilt to new land. Although it is very desirable to prevent the introduction of wilt on new land as long as possible, the most practicable method of control is to grow a wilt-resistant variety.

RUST

In some seasons rust does considerable damage to seed flax in the Red River Valley of North Dakota and in other areas where considerable flax is grown. The disease appears as bright orange pustules on the leaves and green stems early in the season. Later in the season the spots turn darker because of the appearance of the brownish spores which live over winter on the straw. As new infection comes from the old straw and stubble of the previous year a rotation which avoids putting flax on the same land two years in succession should help to control the disease. Argentine flax appears to be nearly immune from rust. The most promising method of control, therefore, appears to be the breeding of varieties resistant to both wilt and rust.

HEAT CANKER

Heat canker is caused by high temperatures at the surface of the soil when the plants are young. It often occurs in plants from 2 to 6 inches high. The stems are girdled and the plants break over. Some of these may continue to grow for a time, but ultimately they break off in the wind. The best control measure appears to be early seeding, which enables the plants to become large enough to shade the ground somewhat before the hot weather of late June and early July occurs.

PASMO

Pasmo, a new disease of flax recently described by Brentzel, appeared in many fields in North Dakota in 1922 and 1923. It has also been found in a few localities in Michigan and Minnesota, and the writer found it at Newell, S. Dak., in September, 1923. Bands of yellowish to brown mottling appear on the stems, leaves, and bolls. Irregular bands of green are left on the stem between the mottled areas. It is not yet known how much damage the pasmo causes. Fair yields of seed are obtained when the disease appears quite prevalent. It probably does more damage to fiber flax than to seed flax. Some varieties appear to be more resistant to the disease than others. Pasmo is known to be carried on the seeds, and the introduction of infected seed into new territory should be avoided so far as possible.

ROTATIONS FOR FLAX

Until recent years the bulk of the flax crop was raised on breaking. Because of the high value of the seed per bushel compared with that of other grain, it makes an excellent crop for the farmer who must haul his grain a long distance to market. Flax seems to be well adapted to growing on prairie sod while it is rotting. It has the further advantage of being a quick-growing crop, requiring generally from 90 to 110 days from seeding to ripening. It can be sown as late as the first week of June with fair assurance of ripening, although early seeding generally is to be recommended.

Flax grown in rotation on old land should follow a crop which will free the land of weeds. A rotation which includes a legume crop, such as field peas, soybeans, sweet clover, or red clover, followed by corn which is given clean cultivation and finally by flax is generally satisfactory. Such a rotation should provide a fertile soil, clean land, and a firm seed bed. Both experiments and experience indicate that flax does well after corn or after a legume crop. It may follow either of these crops in the rotation, the choice depending upon the needs of the farm.

Flax following potatoes often is choked out by weeds, and it generally is better to follow potatoes with a more aggressive crop. The loose soils of potato fields also are not generally desirable for flax.

Experiments carried on by the Minnesota Agricultural Experiment Station[2] in which flax in 1923 followed several crops which had been grown for two years in succession (1921 and 1922) on the same plats gave interesting results. Arny says:

> The results from this work indicate that flax following corn produced the best crop. Flax following red clover, sweet clover, soybeans, and field peas was nearly as good as that following corn. Flax following wheat, oats, barley, rye, buckwheat, and flax was second rate as compared with that following corn, and flax following millet and sorghum was practically a failure. Flax following timothy was third rate. More disease was present in the flax following timothy than in the flax following the other crops mentioned.
>
> Much more extensive work needs to be done in order to learn the best place for flax in the rotation on the different soil types under the varying rainfall in Minnesota. With this information available to the growers, the adoption of flax as a regular cash crop on the farms in the State will be facilitated.

In semihumid areas where alfalfa, clover, or grass is included in the rotation flax often can be used as the nurse crop. It is a comparatively shallow feeder and does not produce dense shade and therefore makes a better nurse crop than the cereal crops which produce a ranker growth.

FLAX UNDER IRRIGATION

Flax is grown under irrigation only to a limited extent, though experiments indicate that it responds well to irrigation. On the Huntley (Mont.) Experiment Farm flax has been grown in a six-year rotation consisting of alfalfa three years, followed by corn, flax, and sugar beets. The third-year alfalfa and the corn are "hogged off," thus adding the fertility from two crops to the land. Ten years' results have now been obtained. The average yield of flax in this rotation in the 10-year period has been 24.5 bushels per acre, the highest yield being 31.8 bushels, obtained in 1918. The yields of beets following the flax have been high (average 14.1 tons per acre), indicating that the flax has no injurious effect on the following crop.

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[2] Arny, A. C. Growing flax as a regular farm crop. Oil, Paint and Drug Reporter, vol. 104, no. 20, p. 49, Oct. 30, 1923.

At the Belle Fourche Experiment Farm, Newell, S. Dak., a similar rotation is used, except that oats instead of beets follow the flax. In this rotation the average yield in the 11 years from 1912 to 1922, inclusive, has been 16.7 bushels per acre, and the highest was 24 bushels. These rotations are very favorable for flax, of course, and such high yields can not be expected under less favorable conditions. On continuously cropped plats flax has averaged 8.4 bushels per acre at Huntley and at Newell.

At Aberdeen, Idaho, flax under irrigation has yielded an average of 22.7 bushels per acre over a period of six years.

At Brooks, Alberta, Canada, the water requirement of flax grown in field plats under irrigation in 1920 and 1921 was determined. The use of 0.85 acre-feet of water applied in 4-inch irrigations was required to produce a 10-bushel acre yield of flax; 1.1 acre-feet produced 15 bushels, 1.25 acre-feet produced 18.5 bushels, 1.3 acre-feet produced 20 bushels, and a maximum yield of 21.5 bushels per acre required 1.34 acre-feet of water.

> It required 5½ inches more water to produce a yield of 18.5 bushels per acre when applied in 6-inch than when applied in 4-inch irrigations. Flax, being a comparatively shallow rooted crop, is best watered with the lighter irrigations.[a]

Under irrigation flax is sown at a somewhat heavier rate, usually 45 pounds per acre. It is desirable to seed early, so that the crop may have a long growing season. When the crop begins to ripen it is desirable to withhold irrigation in order to hasten ripening. If the soil is kept wet, blooming may continue indefinitely.

FLAX AND WHEAT AS A MIXED CROP

Flax in mixture with spring wheat is grown extensively in Goodhue County, Minn., and the surrounding district. Because of the favorable results obtained in this county the mixed crop was grown to some extent throughout much of the flax-producing area in 1923. The chief advantages of the mixed crop over flax grown alone appear to be (1) the greater ease of handling in harvesting and threshing, (2) the better control of weeds, and (3) a possible greater total return per acre.

The mixed crop handles well in harvesting. The longer bundles, tapering toward the top, make it possible to build better shocks and stacks than are possible with flax alone. A photograph of a shock of mixed flax and wheat is shown in Figure 4.

Weeds are controlled to a greater extent in the mixed crop than in flax alone. The partial shading effect and taller growth of the wheat plants hold many weeds in check. Numerous experiments carried on in Minnesota, North Dakota, and Wisconsin indicate that the mixed crop generally contains fewer weeds than flax grown alone. Certain weeds, especially wild oats, appear to grow as vigorously in the mixed crop as they do in either wheat or flax alone.

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[a] Snelson, W. H. Irrigation practice and water requirements for crops in Alberta. Canada Dept. Int., Reclam. Serv. Irrig. Ser. Bul. 6, 59 p., illus. 1922.

An average increase in yield of from 5 to 10 per cent may be expected from the mixed crop, according to experiments carried on at University Farm, St. Paul, Minn.; that is, 2 acres of the mixed crop should produce on the average from 5 to 10 per cent more grain than 1 acre of wheat and 1 acre of flax.

The mixed crop is sown at the usual date for seeding spring wheat, or a little later if there is danger of severe freezing weather after the flax emerges. The usual rate of seeding in Minnesota is 28 pounds of flax with 30 or 45 pounds of wheat per acre. Probably less seed should be sown where the rainfall is less, as in the Dakotas. In experiments at Dickinson and at Mandan, N. Dak., in 1923, mixtures ranging from 15 pounds of flax with 20 pounds of wheat to 25 pounds of flax with 30 pounds of wheat per acre produced satisfactory yields. A seeding rate of 20 pounds of flax with 20 or 25 pounds of Marquis wheat per acre should be enough in this drier area. The two kinds of seed are mixed and sown with a drill from 1 to 1½ inches deep. Marquis spring wheat generally is used, as it ripens at about the same time as flax. Furthermore, it does not shade the flax excessively, as ranker varieties do. A view of a field of mixed flax and wheat is shown in Figure 5.

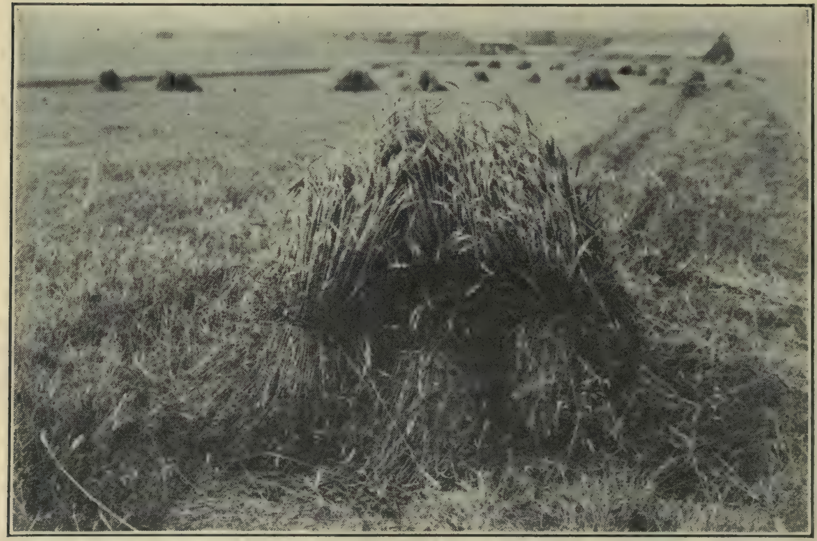

FIG. 4.—A typical shock of mixed flax and wheat, showing the well-shaped bundles made by the binder. Such bundles handle easily in shocking and stacking

DISADVANTAGES OF THE MIXED CROP

The mixed crop is not to be recommended where there is a ready sale for pure flax straw. Straw from the mixed crop has no value for manufacturing purposes, but probably is fully as good as flax straw for feeding to stock or for bedding animals. These facts should be considered in determining whether the mixed crop or flax alone is to be grown.

Another disadvantage, especially where a large acreage is grown, is that the mixed grain must be separated before it is marketed. The separation is made easily with an ordinary fanning mill by using the proper sieves. A steel wire sieve with meshes 4 by 16 to the inch is satisfactory.

GROWING SEED FLAX

PREPARING THE SEED BED

Flax requires a firm seed bed. Poor stands often are due to seeding too deep in loose soil. Sod broken in the fall or spring should be packed by heavy rolling or by disking, harrowing, and rolling and the surface made level before seeding. Spring breaking should be prepared as soon as possible after breaking, in order that the seed may be sown before the turned sod becomes dry. Where tractor outfits are used, plowing, disking, packing, and seeding often are done in one operation.

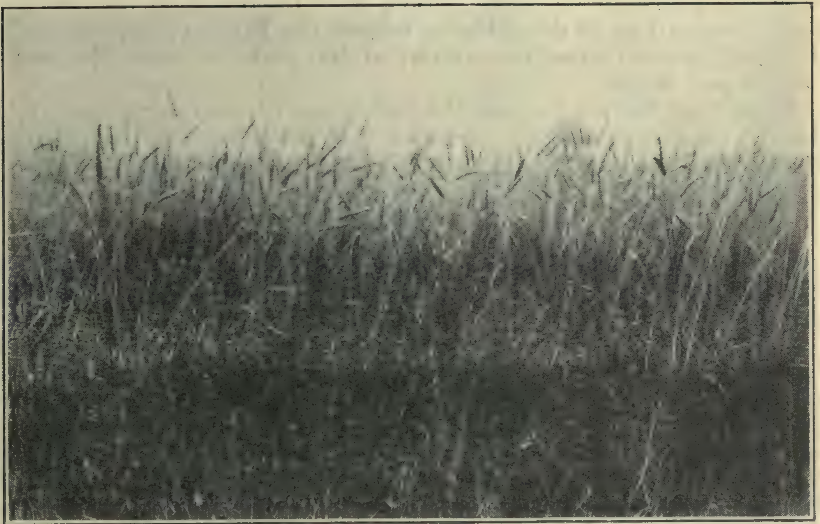

FIG. 5.—A close view of mixed flax and wheat in a field near Red Wing, Minn. Such a mixture usually will yield about half flax and half wheat

A firm seed bed is as essential when flax is grown in rotation with other crops on old land, as it is on new breaking. For this reason corn ground usually is disked instead of plowed in preparation for flax. If spring plowing is necessary, the land should be made firm by rolling or disking, with the disks set nearly straight, and harrowing.

Pasture and meadow lands usually should be broken in the late summer or fall in preparation for flax. The rough sod will catch and hold the snow, frequent freezing and thawing will mellow the sod, and the land can be put in shape for earlier seeding in the spring.

Whether fall or spring plowing of stubble land is best for flax depends upon the conditions under which the crop is to be grown. In the humid area fall plowing and early-spring seeding generally are considered best. Where a large acreage is sown, however, it often is impracticable to plow all the land in the fall. In the drier areas the winter cover of stubble catches and holds the snow, adding moisture to the soil. Under such conditions spring plowing may give the best results.

It is very necessary to prepare a firm even seed bed, so that the seed may be sown at a uniform depth. All harrowing should be done before seeding. Harrowing after the drill covers many seeds too deep and prevents the young plants from reaching the surface.

METHOD OF SEEDING

Flax should be sown about 1 inch deep in a firm seed bed. A press drill is desirable for seeding flax, as it firms the soil around the seeds, thus insuring even germination. The ordinary grain drill, however, generally is used. When it is necessary to sow on loose soil, it sometimes is desirable to release the pressure springs on the drill and depend upon the weight of the disks to place the seed at the proper depth.

In seeding flax and wheat the two kinds of seed are mixed in the desired proportions at the granary and sown together. The mixed seed should be sown 1 or 1½ inches deep.

CONTROL OF WEEDS

Because flax is a poor weed fighter it should be grown on the cleanest land available. Newly turned sod of prairie, pasture, and meadow lands and clean corn stubble are best for flax.

Where old ground is used every effort should be made to rid the land of weeds before seeding. It often is an advantage to disk fall-plowed land early in the spring to start the growth of weeds. After 10 days or two weeks this land may be disked again, or harrowed well, just before seeding to flax, in order to kill the sprouting weeds. The object is to destroy weeds and weed seeds and still sow the flax as early as possible. Where late warm-weather weeds, such as green and yellow foxtail (pigeon grass), are troublesome the flax should be sown early, so that it may become well established before these weeds begin growth. Early-sown flax usually will ripen before green foxtail ripens, and the immature weed seeds may be separated from the flax in recleaning by using a strong air blast.

Where Russian thistles are troublesome, as in the drier parts of the flax-producing area, it often is an advantage to disk corn stubble some two weeks before seeding and again just before seeding. The first cultivation starts the germination of innumerable weed seeds, and the seedlings are killed by the second disking. Indeed, it may be necessary only to harrow for the second cultivation in order to kill sprouting weeds and put the soil in good tilth. Russian thistles are at their best in dry seasons, and as they draw heavily on the soil moisture flax can not do well where these weeds are numerous.

TIME OF SEEDING

It is the custom to seed flax late on breaking or as a catch crop on old land. This practice has led many growers to believe that flax should not be sown until about the first of June. Experiments show that early-sown seed generally produces the highest yields. Early seeding allows the plants to mature seed before the hot dry weather of midsummer occurs. Contrary to common belief young flax is not easily injured by frost. It will endure a temperature of 25° F. when the plants are just coming up and a still lower temperature after the plants are 3 or 4 inches high. On the other hand, late-sown flax is easily injured by fall frost occurring before the crop is ripe.

Experiments conducted on the northern Great Plains area in the past 10 years indicate that flax sown in the latter part of April or the first part of May usually produces the highest yield. For best development flax requires cool weather at the time of blossoming and ample moisture until ripening begins. Such conditions are most likely to be met if the seed is sown early.

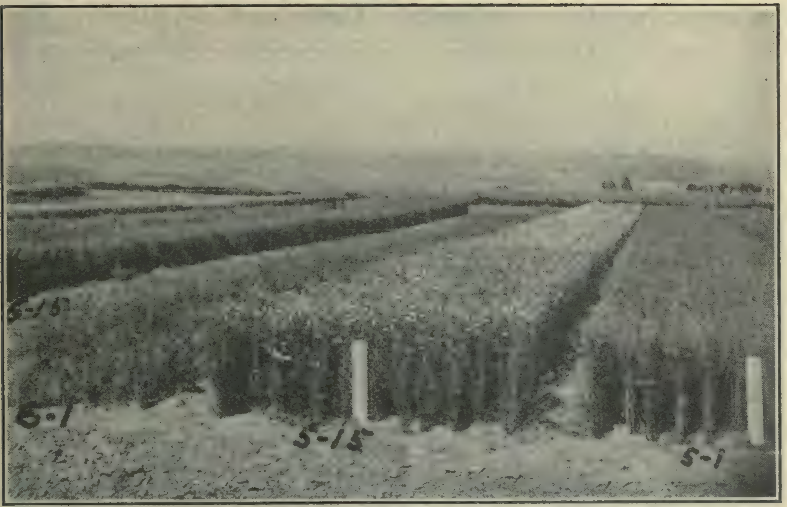

FIG. 6.—Plats of flax sown at intervals of 15 days from April 15 to June 15, 1922, at Mandan, N. Dak. The plat sown on May 15 was in full bloom when photographed on July 7, 53 days after seeding

Flax may be sown during the first week of June, however, with fair assurance that it will ripen before frost. Later seeding than this often results in low yields, even though the crop escapes frost. Plats of flax sown at intervals of 15 days from April 15 to June 15 at Mandan, N. Dak., in 1922, are shown in Figure 6.

As mentioned under the heading "Control of weeds," it often is an advantage on weedy land, especially where Russian thistles are abundant, to delay seeding and cultivate the land with disk and harrow in order to germinate seeds and destroy the weeds before seeding to flax. On the other hand, where green and yellow foxtail (pigeon grass) are bad weeds, flax should be sown early, so that it may become well established before these warm-weather weeds get started.

RATE OF SEEDING

In western Minnesota, eastern South Dakota, and eastern North Dakota the usual rate of seeding flax is a half bushel (28 pounds) per acre. Farther east, where the rainfall is greater, it is considered an advantage to seed from 30 to 40 pounds per acre. The heavier rate of seeding may help to control weeds. In the northern Great Plains area under dry-farming conditions 20 or 25 pounds of seed per acre are sufficient.

Under irrigation flax usually is sown at the rate of 40 or 45 pounds per acre. It is not known whether a lower rate of seeding would yield as good returns.

HARVESTING THE CROP

The plants should be fully ripe when cut, unless unusual conditions make this impracticable. Fully ripe flax will dry quickly in the shock or bunch. If sown late or if the season is wet and cool, it may continue to bloom until frost. Under such conditions it will be necessary to cut the crop when a large proportion of the bolls are ripe, even though the stems are still green.

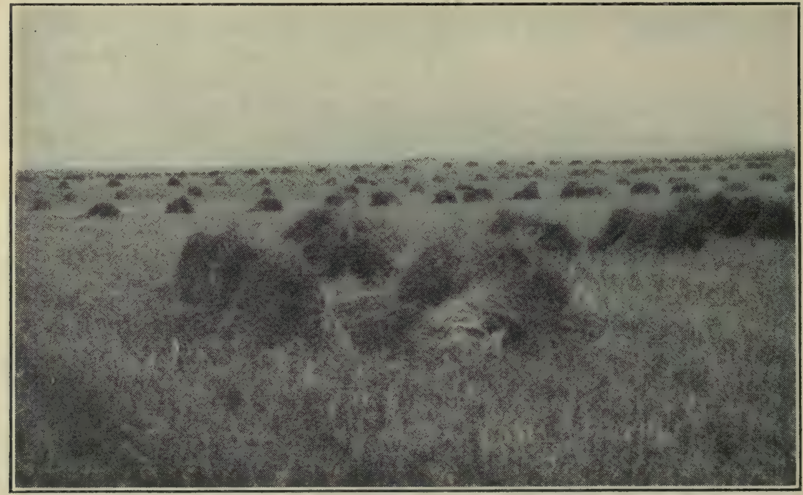

FIG. 7.—Seed flax harvested and bound with a grain binder and put up in narrow shocks to dry

Flax generally is cut and bound with a grain binder. By proper adjustment, bundles of fair size and shape can be made. When bound flax is shocked the bolls are kept from the damp ground and the seed is not damaged.

In the drier area flax sometimes is cut with a header. It then may be stacked in long, low ricks, or an automatic dropper may be attached to the header elevator and the flax dropped in small bunches on the ground. Reapers also are used for cutting flax. The reaper and the header save the expense of twine and the labor of shocking, and the small loose bunches dry out rapidly in clear weather. In case of rain, however, the bunches should be turned to dry or much seed will be damaged.

If the flax is bound it should be put in small shocks made so as to allow ventilation through the center or in long shocks of only two bundles in width (fig. 7).

Flax should not be stacked until it is thoroughly dry. The stacks may be protected from rain by a covering of hay or a tarpaulin. This is desirable especially if the flax is intended for seed.

Flax most often is threshed from the shock or bunch, and this is the most economical method. It is desirable to thresh as soon as the flax is thoroughly dry, so as to avoid the risk of loss from rain. Flax is damaged both for oil and for seed purposes if allowed to remain wet in the bunch or shock for a few days.

For best results in threshing, flax should be thoroughly dry. It should be fed into the machine evenly and not too fast. The bolls, leaves, and stems break up and overload the sieves, so that a good job of cleaning can not be done unless judgment is used in feeding.

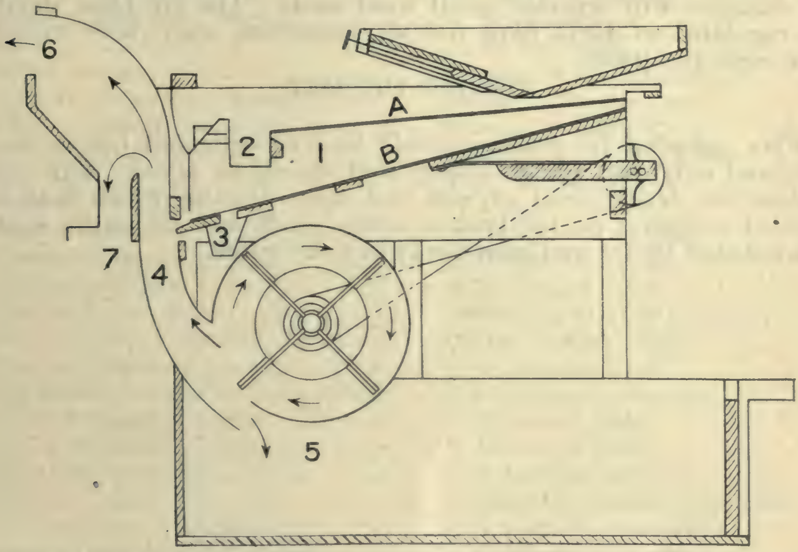

FIG. 8.—A good type of grain-cleaning mill which will reclean flax for seed and separate the mixed grain, flax, and wheat. 1. Shoe, carrying upper (*A*) and lower (*B*) screens. The shoe is given an end shake by means of an eccentric bearing operated by the crank shaft. 2. Spout which carries off coarse material separated by the upper sieve (*A*). An upper sieve with meshes 4 by 16 per inch will separate wheat from flax. 3. Screening spout which receives small weed seeds separated by the lower sieve. 4. An air current driven up through the falling grain carries off chaff and dust through the hood (6). Light seeds fall through the open space (7). 5. Grain box which receives clean grain. Cone pulleys on the fan and drive shafts make it possible to drive the fan at any speed necessary to remove light seeds and trash

Where flax is intended for seed, the machine should be cleaned thoroughly and run empty for a few minutes, in order to remove any weed seeds or diseased flax seeds that may have lodged in the machine.

RECLEANING THE SEED

When flaxseed contains a high percentage of dockage, especially if the dockage is grain that is valuable for feeding, it usually will pay to reclean the flax before marketing. Hundreds of cars of flax are shipped to market that contain from 10 to 40 per cent dockage. It probably would pay to reclean such flaxseed, grind the screenings, and feed them on the farm. Cracked flax, grain, and some weed seeds are valuable feeding stuffs, and yet the grower receives little or no pay for them as dockage. Such screenings should be finely ground, to avoid scattering weed seeds about the farm.

Flaxseed should be thoroughly cleaned with a good fanning mill before sowing. A good type of farm fanning mill is shown in Figure 8. This type of mill cleans the seed by two principles, first, separation by sieves according to size, and, second, separation according to weight. The seed falls through a strong air blast which blows out the lighter seeds. A steel-wire sieve with meshes 4 by 16 per inch will separate grain and the larger weed seeds from flax. A metal sieve with round holes one-fourteenth of an inch in diameter will separate small weed seeds. The air blast should be regulated so as to blow out all immature, scaly, and cracked flax seeds and trash.

STORING THE SEED

Flax intended for seeding should be well recleaned before storing, and only dry, sound, plump seed should be saved. This will reduce the development of wilt and other diseases which may be carried as spores on the broken stems, chaff, and immature seeds. Flax should be dry and stored only in a dry place.

ORGANIZATION OF THE UNITED STATES DEPARTMENT OF AGRICULTURE

October 20, 1924

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U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1329

The BOLL-WEEVIL PROBLEM

WARNING.

THE present great interest in the boll-weevil problem in the Southeastern States has brought out a large number of proprietary preparations and machines, the sale of which is being vigorously pushed. This is a repetition of what has occurred in every region invaded by the boll weevil. During the first few years the farmers are exploited and many useless or practically useless devices are sold to them. In a few years, however, the organizations producing such devices go out of business. Their operations are especially important at the present time, since the losses caused by the boll weevil will be increased by the expense of buying nostrums of various kinds.

The claims for these preparations are not based on scientific tests, although in many cases the persons exploiting them are undoubtedly sincere in their belief that they will yield good results. Generally speaking, they are based on misinterpretations of what occurs in the field. To determine whether a remedy is effective, it is necessary to have control areas and to consider the effects of numerous cultural practices. It is very easy for an untrained observer to attribute to some preparation he has applied the beneficial results of some variation in climatic or cultural factors.

The Department of Agriculture and many of the State experiment stations have tested the new boll-weevil remedies which have been proposed from year to year, and many of those now being offered the public are not essentially different from the kinds that have been tested and discarded.

The Association of Southern Agricultural Workers at its convention at Memphis in February, 1923, discussed the whole problem of boll-weevil control, and, in addition to certain cultural methods, it recommended the consideration of three remedies.

This convention heartily indorsed the calcium arsenate dusting method in areas where the yield of cotton is high enough to warrant the expense. It also indorsed the Florida method for the region in which it has been proved to be applicable, and suggested extensive tests of this method in other regions of light yields.

The convention also called attention to the fact that the molasses-arsenate treatment, although not yet subjected to sufficiently detailed experimental tests to warrant its indorsement, has apparently given results over a wide area that warrant further consideration, and it therefore recommended thorough and immediate official tests of this method.

The State and Federal agencies are anxious to help the farmers by means of any new methods of controlling the boll weevil which may be discovered. As promptly as possible careful tests are conducted. The Department of Agriculture strongly recommends that farmers exercise due caution in spending money for new boll-weevil remedies. In all cases they should demand evidence of official tests and communicate with their experiment stations for detailed information regarding any of the new remedies. If anything of value is discovered by the State experiment stations or by the Federal department, prompt and widespread notice of the fact will be given the public. In the meantime any money spent for patented mixtures or machines will in all probability be wasted.

Washington, D. C. Issued June, 1923

THE BOLL-WEEVIL PROBLEM.

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ORIGIN, SPREAD, AND PRESENT DISTRIBUTION OF THE BOLL WEEVIL.

THE COTTON BOLL WEEVIL[1] is not a native of the United States. Its first home was undoubtedly in the plateau region of Mexico or Central America. Previous to 1892 the insect had spread through much of Mexico, but little is known regarding the extent or rapidity of this dispersion. The records indicate, however, that it probably had caused the abandonment of cotton in certain regions. About 1892 the boll weevil crossed the Rio Grande near Brownsville, Tex. It may have flown across or it is possible that it was carried over in seed cotton to be ginned at Brownsville. By 1894 it had spread to half a dozen counties in southern Texas. A preliminary examination, made during that season under the direction of Dr. L. O. Howard, Chief of the then Division of Entomology, by C. H. T. Townsend, showed the enormous capacity of the pest to do damage. Subsequent events have verified in every way the predictions that were made at that time, when the insect had not attracted much attention in the South. Since 1894 the boll weevil has extended its range annually from 40 to 160 miles, although in several instances the winter conditions have caused a decrease in the infested area. During the first 10 years after its advent into this country the annual rate of spread of the weevil was 5,640 square miles. From 1901 to 1911 the annual increase in the infested territory averaged 26,880 square miles. In 1916 it reached 71,800 square miles. Of course, the figures given do not refer to the area in cotton. In many parts of the infested territory the area devoted to cotton is much less than 10 per cent of the total area.

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[1] *Anthonomus grandis* Boh.; order Coleoptera, family Curculionidae.

The territory in the United States in which the boll weevil occurred at the end of the year 1922 is shown in figure 1. At the end of that year 614,213 square miles of territory had been infested by the boll weevil, leaving only about 91,000 square miles of cotton-producing territory uninfested. Practically 87 per cent of the Cotton Belt is now infested by the weevil, and the area now infested produces 95.99 per cent of the cotton crop of the Cotton Belt of the United States.

A form of the boll weevil is found in the mountains of Arizona feeding upon a wild plant related to cotton. This variety has been under observation for a number of years, and finally was noted in 1920 attacking cultivated cotton north of Tucson, Ariz., between that city and the Santa Catalina Mountains. The State of Arizona is attempting to eradicate this infestation by a noncotton zone in the infested district.

The boll weevil is known throughout the larger portion of Mexico and southward to Guatemala and Costa Rica. It is known to occur also in the eastern half of Cuba.

DAMAGE.

The losses caused by the boll weevil are both direct and indirect, and extend throughout practically the entire financial and economic structure of the Cotton Belt. It is impossible to estimate the losses due to depreciated land values, closing down of cotton gins and oil mills, and other indirect results of the weevil invasion. All estimates have been made entirely on the basis of the direct loss in nonproduction of cotton lint and seed. The Bureau of Crop Estimates of the United States Department of Agriculture in the fall of 1920 estimated an average annual loss for the last four years of about $300,000,000. Other estimates have differed somewhat, but certainly the annual direct loss is now well in excess of $200,000,000.

The damage in individual fields is influenced by many factors and varies widely, ranging from slight injury to complete destruction of the cotton crop. A fair idea of the possibilities of loss is afforded by the gains which have been secured in recent poisoning experi-

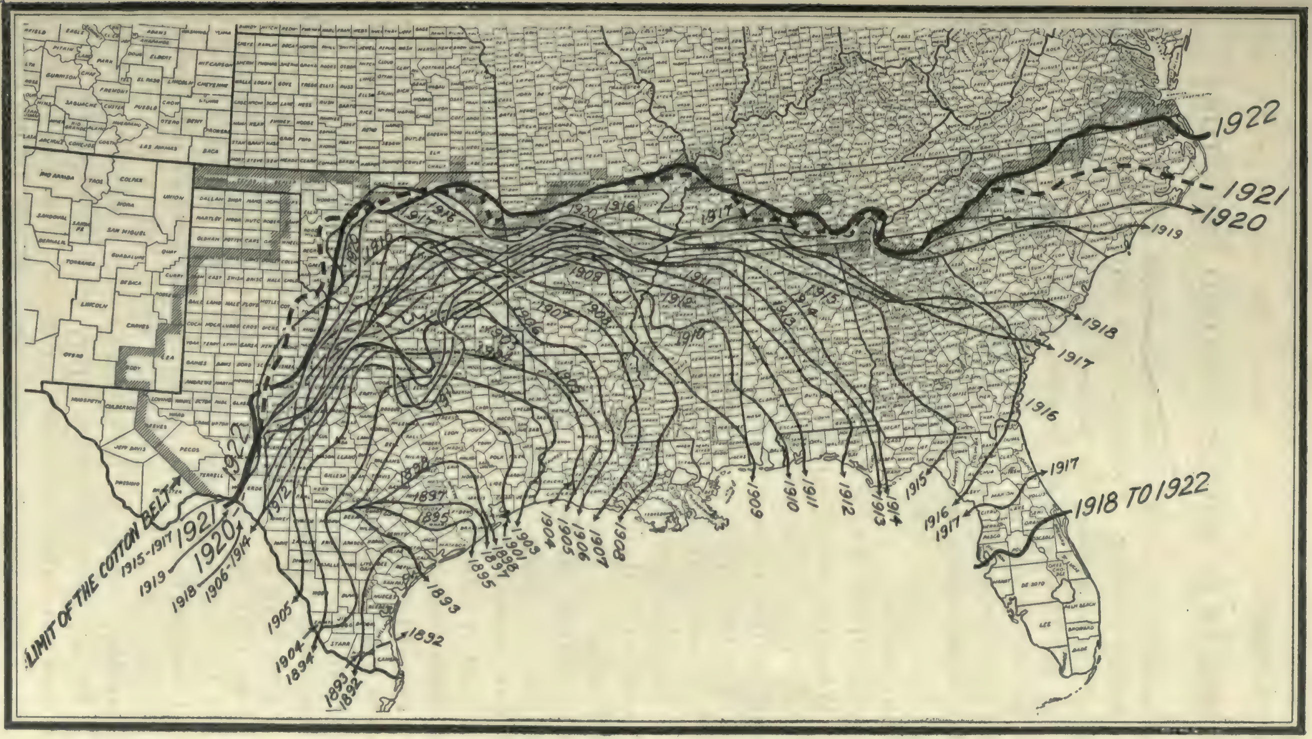

FIG. 1.—Map showing spread of the Mexican cotton boll weevil in the United States from 1892 to 1922, inclusive.

NOTE: The outer limit of the cotton belt advances or recedes slightly from year to year, and as shown on the map is not entirely accurate for 1922, as shown by the fact that in a few places the boll-weevil line is a little in advance of the indicated limit of cotton culture.

ments where weevil injury has been eliminated. Gains of five, six, or even seven hundred pounds of seed cotton per acre due to poisoning are not unusual, and in exceptional instances gains have exceeded one thousand pounds.

PROSPECTS IN NEWLY INVADED TERRITORY.

The boll weevil is now distributed over almost all of the important cotton-producing sections. Practically the only territory remaining uninfested is the zone along the western margin of the Cotton Belt. Some of this territory has been invaded in the past and the weevils have been driven back by adverse weather conditions. Whether the weevil will ever become seriously injurious in this territory is problematical, but it has shown marked ability to adapt itself to unfavorable conditions. Just how far this adaptation will extend it is impossible to predict.

The progress of the weevil invasion has caused one erroneous impression. When the weevil invades a new district complaint is made of its serious injury to the cotton crop during the first two or three years, and then little more is heard of it. This naturally leaves the impression that the weevil is seriously injurious in a new territory for only a few years and then passes onward. This impression, however, is not substantiated by facts. It is true that when weevils first invade a community there is nearly always more or less panic and a decided tendency to blame the weevil invasion for all short crops of cotton regardless of the real causes. Furthermore, the successful production of cotton in the presence of weevils requires somewhat different methods from those practiced before the advent of the weevil, and it usually takes the farmers two or three years to learn and adopt these methods. After a few years the farmers become accustomed to the weevil injury, learn to distinguish between loss due to the weevil and that attributable to other causes, and are able to reduce weevil injury somewhat by proper farming practices. The first fear has been overcome, and comparatively little is said on the subject. Farmers in the eastern portion of the cotton belt even express the idea that the weevil is no longer doing any damage in Texas. Yet the cotton-growing season of 1921 showed a total of more weevil damage in the State of Texas than that of any previous year. Once established in a community weevil injury will continue, and when weather conditions favorable to weevil survival and multiplication are experienced serious injury must be expected. Since one of the most favorable conditions for weevils is excessive summer rainfall, the regions with the heaviest precipitation during the cotton-growing months will suffer the greatest damage.

WORK UPON WHICH THIS BULLETIN IS BASED.

The danger from the boll weevil was appreciated from the beginning by the chief of the entomological service of the department. Work on the life history, although at first not extensive, showed the essential steps in the control of the pest. Later Congress made available large appropriations for the exhaustive investigation of the insect and of means of reducing its damage. Work was begun by the establishment of a laboratory at Victoria, Tex., and field experimental work was carried on in direct connection with the laboratory investigations. Later the headquarters of the investigation were moved from Victoria to Dallas, Tex., on account of the continued spread of the insect, and then to Tallulah, La. The Bureau of Entomology has conducted experiments during several seasons on a total of more than 50,000 acres of cotton located on well-known plantations throughout the infested territory. The special requirements in different regions have received particular attention.

Aside from the work relating directly to the boll weevil which has been conducted by the Bureau of Entomology, the Bureau of Plant Industry of this department has carried on investigations dealing with the breeding of cottons to obtain earliness and productiveness. The farm-demonstration service has carried the results of this work directly to the farmers throughout the South.

In addition to the work done by the Department of Agriculture, the State entomologists have dealt with the boll weevil in connection with the numerous other entomological problems of the States. They have contributed valuable results which have been incorporated in this bulletin.

DESCRIPTION AND LIFE HISTORY OF THE BOLL WEEVIL.

The adult boll weevil is about one-fourth of an inch long, varying from one-eighth to one-third of an inch, with a breadth about one-third of the length. This measurement includes the snout, which is approximately half the length of the body. Variation in size is due to the amount of food the insect has obtained in the larva stage. Individuals from bolls are therefore nearly always larger than those from squares. The color (grayish or brownish) depends upon the time that may have elapsed after transformation to the adult stage. The recently emerged individuals are light yellowish in color, but this changes to a gray or nearly black shade in a few weeks' time (fig. 2).

Hundreds of species of weevils in this country may be easily mistaken for the boll weevil. Many erroneous reports about the occurrence of weevils far outside the infested area have been due to this similarity. The only sure way to determine whether an insect is the boll weevil is to send it to an entomologist for examination. In the field the most conspicuous indication of the presence of the boll weevil is the flaring (fig. 4) and falling of numbers of squares. Unfavorable climatic conditions and careless cultivation, however, frequently cause great shedding, which is often mistaken for weevil damage. If excessive shedding be noted and the squares upon being cut open show a white, curved grub (fig. 5) that has fed upon the contents, there is little doubt that the boll weevil is the insect causing the damage.

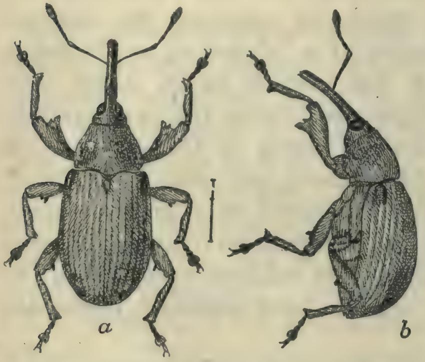

Fig. 2.—Cotton boll weevil: *a*, Beetle, from above; *b*, same, from side. About five times natural size.

The boll weevil passes the winter as an adult or beetle. In the spring and throughout the fruiting season of cotton the eggs are deposited by the female weevils in cavities formed by eating into the fruit of the plant (see fig. 4). An egg hatches under normal conditions in about three days, and the grub immediately begins to feed. In from 7 to 12 days the larva or grub (fig. 3, at left) passes into its pupa stage (fig. 3, at right), corresponding to the cocoon of butterflies and moths. This stage lasts from three to five days. Then the adult issues, and in about five days begins the production of another generation. Climatic conditions cause considerable variation in the duration of the stages, but on an average it requires from two to three weeks for the weevil to develop from the egg to the adult. Males and females are produced in about equal numbers. The males feed upon the squares and bolls without moving until the food begins to deteriorate. The females refrain, throughout most of the season, from depositing in squares visited by other females, but late in the fall, when all of the fruit has become infested, several eggs may be placed in a single square or boll. As many as 15 larvæ have been found in a boll. The squares are greatly preferred as food and as places for depositing eggs. As long as a large supply of squares is present the bolls

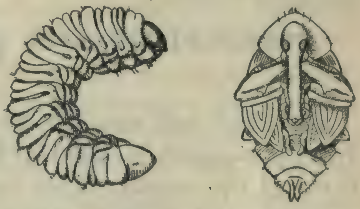

Fig. 3.—Cotton boll weevil: Larva at left, pupa at right. About five times natural size.

are not damaged to any serious extent. The bolls, therefore, have a fair chance to develop as long as squares are being formed.

The cotton-boll weevil, so far as known, breeds in no plants other than cotton and the wild cotton of Arizona. At the present time, at least, the insect is restricted to the cotton plant as a means of development.

In laboratory experiments performed by the junior author, a weevil developed in the bud of a wild plant related to cotton. Under natural conditions it has not been found developing in that plant, but the experiments may indicate a tendency for the insect to acquire a new food plant. Adult boll weevils frequently have been found in okra blooms, but repeated observations and experiments have failed to show that the weevil places its eggs in the pods or can develop in them. When confined in bottles, the adult weevil will feed on various substances, such as apples or bananas, but this is only under the stress of starvation.

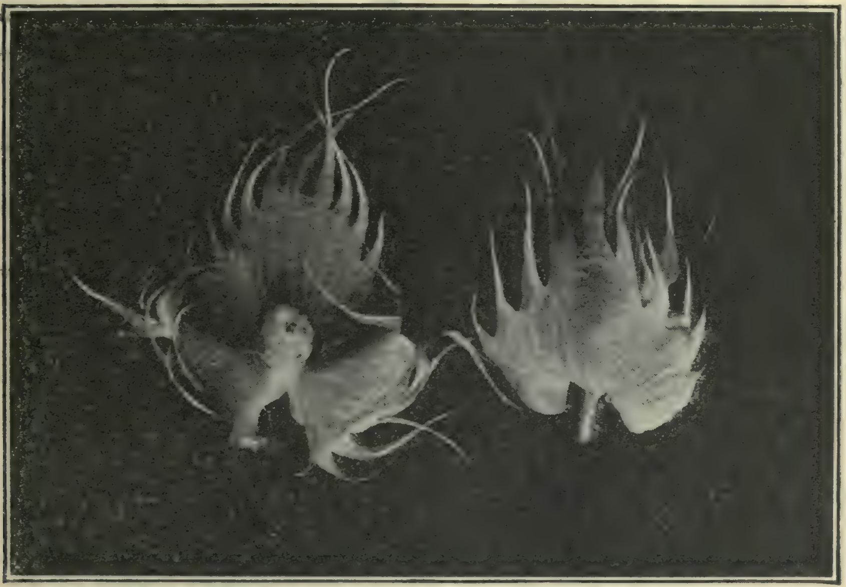

FIG. 4.—Weevil injury to cotton square. The square to the left has been punctured and shows typical "flaring" of bracts, while the one to the right is uninjured.

The chief activity of the boll weevil is from 9 o'clock in the morning to 5 in the afternoon. It has been found in experiments performed in Louisiana that during this period of the day 65 per cent of the eggs are deposited. Eleven per cent of the eggs are deposited early in the morning—that is, from 5 o'clock to 9. There is some activity at night. Six per cent of the eggs are deposited between 8 o'clock at night and 5 o'clock in the morning.

Unlike some related insects, the boll weevil is not attracted to light. The fact that somewhat similar species do come to lights in great numbers at times has frequently caused the belief that the pest could be controlled by the use of trap lights.

An interesting habit of the boll weevil is to feign death—that is, to "play possum," or "sull," as it is popularly called. When disturbed, the insects usually contract their limbs and drop to the ground. This habit is not equally strong in all individuals.

The age to which weevils live varies according to conditions. During the winter the longevity is much greater than in the summer. During the summer season the majority of weevils do not live longer than 50 days. During the cooler part of the year many of them live as long as six months. The longest-lived weevil on record lived from December 10 to the following October, a period of about 11 months. Undoubtedly such prolonged life is exceptional in the usual form of the weevil. The Arizona weevil, however, has been known to survive for more than a year.

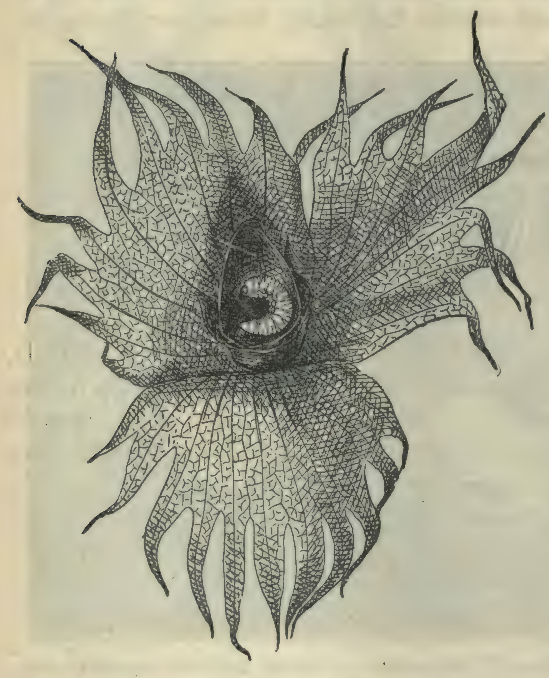

FIG. 5.—Cotton square showing larva of boll weevil in position. Natural size.

HIBERNATION.

As has been pointed out, the boll weevil passes the winter in the adult stage. At the time in the fall when frosts occur immature stages may still be found in the squares or bolls. If the food supply is sufficient, many of these immature stages continue their development at a very slow rate and finally emerge as adults. Thus there may be a somewhat continuous production of adults during the winter. Ordinarily, however, this is not the case, since the frosts that destroy the cotton generally kill practically all of the immature stages of the weevil.

With the advent of cool weather in the fall the adult boll weevils in cotton fields begin to seek protection against the winter. They fly from the fields in every direction, although their movements are governed partially by the prevailing winds. They may fly into hedges, woods, cornfields, haystacks, farm buildings, or other places. Specimens have been found in such situations, and also in considerable numbers in Spanish moss growing some distance above the ground on trees. A number of weevils also obtain hibernating quarters without leaving the cotton fields. These may crawl into cracks in the ground, under grass, weeds and other trash, and into the burrs from which the cotton has been picked. In some cases several thousand weevils per acre have been found hibernating in such situations. Here, however, the mortality is greater than where the protection is better. In fact, hibernation in the fields is not of great importance except in the more southern localities. That the majority of weevils which hibernate successfully do not pass the winter in the cotton fields has been shown by many experimental observations and is demonstrated every year in the infested territory by the appearance of the first damage in the immediate vicinity of woods and in other places where conditions for protection are favorable.

During the winter the weevils take no food and remain practically dormant. On especially warm days they may move about to a certain extent. During the very mild winter of 1906–7 hibernating weevils were found moving about more or less throughout the period from November to March.

The number of weevils that live through the winter has been determined very accurately for different conditions. It varies with the temperature and with the region. Heavily timbered regions, especially where Spanish moss occurs, show the smallest winter mortality. In Louisiana, out of 25,000 weevils, 2.82 per cent survived the winter of 1905–6. These weevils were placed under various conditions that must have approached those which the species encounters naturally. The winter referred to was practically a normal one so far as temperature and precipitation were concerned. In extensive work in Texas during the winter of 1906–7, out of 75,000 weevils 11.5 per cent survived. As in the preceding case, these weevils were placed under diverse conditions in different cages. These conditions ranged from the most favorable to the least favorable; that is, from an abundance of protection to practically none. The survival obtained was undoubtedly very close to that occurring under the diverse natural conditions of that winter. It must be emphasized that the winter of 1906–7 was abnormally warm. The average survival in experiments performed in Texas and Louisiana from 1906 to 1911 was 6 per cent, which must represent about the average survival occurring in nature.

From 1914 to 1920 a rather extensive series of cage experiments was conducted by the Department of Agriculture at Tallulah, La., utilizing from 20,000 to 30,000 weevils each year. These were placed in hibernation under a rather wide range of conditions, which probably represent a fair average of those found by the weevil in seeking hibernation quarters around the cotton field. The annual survival in these series varied from 0.3 per cent to 5.9 per cent.

Emergence from hibernation depends primarily upon temperature and rainfall in the spring, although some minor factors are concerned. In the southern portions of the Cotton Belt emergence usually begins from the first to the middle of March, but farther north it is somewhat later than this. Naturally, the individuals under the heaviest protection are affected latest by the temperature. The consequence is that emergence from hibernation is prolonged. It has been known to extend from the middle of March to the 28th of June, and in even more extreme cases from the middle of February to about the first of July. There is usually a comparatively short period during which the emergence is most rapid but this may be broken up into several such periods with intervals of slow emergence due to changes in weather conditions.

HOW NATURE ASSISTS IN DESTROYING THE BOLL WEEVIL.

Although the possible production of offspring in a single season by one pair of weevils has been estimated at 12,755,100, nature has provided several means of preventing such excessive multiplication. The most conspicuous of these are heat and insects that prey upon the weevil.

EFFECTS OF HEAT.

When infested squares fall to the ground they may become so heated that the larvæ are killed in a few minutes. The insect in the larva stage can not leave the square, as it has no means of locomotion whatever. Where the infested squares are subjected to the unobstructed rays of the sun the mortality is very high. This explains the well-known fact that dry seasons are unfavorable to the weevil and indicates great difficulty in controlling the insects in regions where precipitation is heavy. Occasionally as many as 90 per cent of the immature weevils in cotton fields inspected have been found to have been destroyed through this agency. The extent of destruction holds a close relation to the amount of shade. When there is no shade practically all of the larvæ and pupæ are killed outright. Some of the important means of control to be described later are based upon this consideration. (See p. 13.)

INSECT PARASITES.

The second of the means provided by nature for the control of the weevil is a large number of insect enemies. Forty-five species which prey upon the boll weevil are known. Of these, 23 are parasites, which by means of their special organs place eggs on the immature stages of the weevil within the square or boll. The young of the parasite develop by feeding upon the boll weevils, which they ultimately kill. Thus parasites instead of boll weevils emerge from the injured fruit. These enemies of the weevil have existed in this country for an indefinite time. Their natural habit has been to prey upon weevils more or less related to the boll weevil which have been present in this country for many years. They never feed upon vegetation. Since the boll weevil offered abundant and favorable opportunities for reproduction, while their original hosts were generally not very numerous, they have naturally turned their attention to the boll weevil. The weevil mortality due to these parasites is exceedingly variable. In many cases no mortality from parasites is observed, while on the other hand fields showing from 50 to 75 per cent of the weevils killed by parasites are by no means rare.

OTHER INSECT ENEMIES.

The boll weevil is attacked by a number of insects which are not parasites in a strict sense but prey upon it as food. The most important of these predatory enemies are ants. Twelve species are known to attack the weevil. They are the minute brown ants and the yellowish ants that occur frequently in cotton fields and are observed running over the plants or on the ground. Their work is not against the adult weevils, but against the immature stages in the squares. Some species devote their attention principally to the squares that have fallen to the ground, while others habitually seek the insects within the squares that remain hanging on the plants. The larva of the weevil, incased in a thin covering, offers food that the ants are not inclined to overlook. They gnaw through the thin shell inclosing the weevil larva, and the latter is soon destroyed. In some cases more than half of the immature stages in fields have been destroyed by ants alone. To find 25 per cent so destroyed is not a rare occurrence.

OTHER FACTORS IN NATURAL CONTROL.

Among minor factors in natural control may be mentioned the development of plant tissue known as proliferation, which sometimes crushes the immature weevils; and determinate growth of the cotton (the tendency to cease squaring about the middle or latter part of the season), which may prevent the development of fall broods of the weevil. Birds are also agents in the destruction of the boll weevil, a fact which has been fully treated in the publications of the Biological Survey of this department.

VARIATION IN NATURAL CONTROL.

Winter killing during hibernation and summer killing due to heat are by far the most important types of natural control. If it were not for these agencies it would be impossible to raise cotton in the presence of the boll weevil. All control agencies, however, vary widely from field to field and season to season in their effect, and this explains the extreme variation in the amount of injury caused by the boll weevil. A mild winter followed by a rainy, cloudy summer favors rapid multiplication of weevils and the damage to the cotton crop is correspondingly increased, while the reverse weather conditions may practically prevent damage to the crop.

DISSEMINATION.

The boll weevil moves from place to place by flight. Although it is a weak flyer compared with many insects, it has been known to cover a distance of more than 40 miles in a very short time. Its flight can not be prolonged, but successive short flights, especially in connection with favorable winds, often carry the insect considerable distances. This is the case, however, only during the so-called dispersion period, which extends from about the middle of August to the end of the season. During the rest of the year the weevil is little inclined to fly. There is always a movement from fields in all directions in search of hibernating quarters in the fall and a corresponding movement from such quarters to the cotton fields in the spring. When the insects reach cotton fields in the spring there is little further movement until the general dispersion begins. Ordinarily between the middle of August and the 1st of September the weevil seems to be seized with the instinct to migrate. It was thought at one time that this movement was forced by excessive reproduction and took place only when all squares and bolls, or the majority of them, became infested. Investigations have shown, however, that the dispersion takes place frequently when the fields are only slightly infested. In other words, the insect has a well-developed instinct for extending its range into new territory. It is this instinct that has caused the extension of the infested area in the United States year by year. The weevil is governed in flight by the wind. If there is no wind, or only a light one, a weevil is as likely to fly in one direction as in another.

The fact that the weevil moves about very little except at one season is of great benefit to the planter. The movement referred to is of little importance after a region has become infested, because it does not begin until after the time when a crop normally is made. The limited movement during the rest of the year makes it possible for any individual farmer to obtain the best results from his own efforts in fighting the pest. The danger that his efforts will be thwarted by the arrival of weevils from fields where no precautions have been taken is not important enough to warrant any farmer in deferring action on account of the indifference of his neighbors.

METHODS OF CONTROL.

Control of the boll weevil is beset with many difficulties. The weevil's insidious methods of work in immature stages within the fruit of the cotton plant, the habit of the adult in seeking protection for the greater part of the time under the bracts of the squares, its enormous power of reproduction and adaptability to new conditions, all place it in a class by itself. These difficulties are further increased by many peculiar requirements of the cotton crop itself and the fact that a successful method of control must naturally be one which is practicable under the average conditions of cotton culture.

In spite of these difficulties, however, satisfactory means of control have been developed. These are the direct and the indirect methods, both of which are of vital importance. The importance of indirect methods is often more difficult for the farmer to appreciate than that of the direct; but, in reality, successful weevil control can not be accomplished unless full advantage is taken of every practical method, and the campaign must be based upon a combination of the different methods rather than concentrating all efforts on direct control.

The farmer is aided in his fight against the weevil by a number of important natural factors which tend to reduce the possible weevil damage. Some of the more important of these which must be taken into consideration in planning a fight on the weevil are as follows:

(1) *The weevil is practically dependent on cotton for reproduction.*

(2) *The mortality of the weevil during the winter is very high.*

(3) *Hot, dry weather during the summer exercises a tremendous control upon the weevil stages, while moist, cloudy weather removes this control and greatly accelerates multiplication.*

(4) *The weevil is attacked by many different species of insect enemies.*

(5) *The emergence from hibernating quarters during the spring is slow and prolonged until well into the summer.*

(6) *Early in the season, on account of comparatively low temperatures, the development of the weevil is much slower than during the midsummer months.*

(7) *The cotton plant produces many more squares than it can carry to maturity as bolls. This surplus is shed by the plant throughout the season, under normal conditions about 60 per cent of the fruit being shed.*

(8) *Up to a certain point weevil puncturing of fruit does not reduce the cotton crop, because large numbers of forms would be shed normally.*

(9) *The weevil has a decided tendency to seek moisture wherever it may be found on the surface of the plant.*

DIRECT CONTROL BY POISONING WITH CALCIUM ARSENATE.

Although the success of poisoning the weevil under certain conditions has been proved beyond doubt, there is danger that farmers may depend too much upon it and neglect the cultural practices which are absolutely essential in any system of weevil control. The basis of this control is still the cultural practices described in this bulletin. Poisoning is supplementary and depends for its success upon the other necessary steps. Unless the planter gives due attention to the seed, preparation, time of planting, and other recommendations made, it will be useless for him to depend upon poisoning to make a crop. The crop itself must actually be made by other expedients; poisoning is merely a device to protect it when it is made.

In the years which have elapsed since the advent of the boll weevil into the United States every conceivable means of direct control of the weevil has been tried repeatedly. Owing to the peculiarities of the weevil attack which have been mentioned, most of these attempts have been unsuccessful. Some methods were found which would control the weevil, but these were either impracticable or too expensive for use on a commercial scale. During comparatively recent years, however, a method of poisoning has been developed which has proved very successful. This consists of treatment of the plants with powdered calcium arsenate by a specialized method.

It has long been known that poisoning the boll weevil is possible to a certain extent, but on account of the peculiar habits of the insect it was difficult to develop methods for the application of the poison.

A profitable method, however, has now been developed by the Bureau of Entomology and is briefly described in the following pages. This has been tested for seven years and is now being adopted rather extensively by the farmers.

Motion pictures have been prepared that visualize the proper methods of poisoning and show the results which can be produced. Anyone interested can borrow copies of the films free of charge, excepting transportation charges, by application to the Office of Motion Pictures, United States Department of Agriculture, Washington, D. C.

The first question which occurs to the cotton farmer contemplating poisoning is whether it will pay to do so. From the following any cotton grower should be able to determine the question for himself:

> **It will pay to poison—**
>
> **If the weevils are really injuring your crop seriously; and**
>
> **If your land is sufficiently fertile to yield at least one-third bale per acre with weevil injury eliminated; and**
>
> **If your farming organization is such that you feel assured that the poison applications will be made at the right time and in the right manner; and**
>
> **If you are willing to spend the full amount necessary to provide an adequate supply of dusting machinery and poison.**
>
> **You should not poison if the cost of the calcium arsenate, the cost of the labor to apply it, and the depreciation on the dusting machines will total more per acre than the current value of 100 pounds of seed cotton.**
>
> **Hand guns should be figured as depreciating 50 per cent in a season and the larger machines about 25 per cent.**

The next extremely important question is that of the dusting machinery which should be used.[2] Extensive experience has shown that it is impossible to get satisfactory results by using makeshift devices to apply the poison, and the only safe procedure is to provide an ample supply of the specialized dusting machinery which is now on the market for the treatment of cotton for the control of the boll weevil. Machines of various types, prices, and capacities are now being manufactured which meet the requirements and circumstances of almost all classes of growers. The following is a brief description of the several types and their uses:

The hand gun is the smallest type of cotton-dusting machine, and, as the name implies, must be carried and operated by the laborer. These machines are generally quite unsatisfactory, owing to their necessarily frail construction and laboriousness of operation. The selling price ranges from $12 to $20 each. *They should be used only*

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[2] See Farmers' Bulletin 1319, Cotton Dusting Machinery.

when no other machine is suitable. Not more than 8 acres should be allotted to one hand gun, and it has generally been found inadvisable to attempt the treatment of more than 25 acres of cotton in one organization with hand guns.

The one-mule machine is the smallest of the traction type of dusters. The operator handles it as he would a walking cultivator or any other walking implement. The machine has two nozzles and will treat either two or three rows of cotton at a trip, thus covering from 15 to 20 acres of cotton in a night of operation. It should be allotted not more than 60 acres of cotton for treatment throughout a season. This machine is now selling at from $75 to $125.

The cart machine is a two-wheel, two-mule machine which straddles a row of cotton. It has three nozzles and will cover from 25 to 30 acres of cotton in a night of operation. It should be allotted not more than 100 acres of cotton for treatment through the season, and is the type most suitable for large farms. This machine is now selling at from $200 to $350.

In the early stages of the dusting work an engine power machine was tried and a few of these are still in use, but it has been found that they are generally too complicated for satisfactory operation except by expert labor. Still other types of machines to suit different conditions are in the process of development, but the present supply will meet almost any condition fairly well.

The following condensed rules have been prepared for the guidance of those planning to poison:

Use only pure calcium arsenate in the form of a dry powder.

Apply this only in the dust form.

Purchase this to conform to the following specifications:

- **Not less than 40 per cent total arsenic pentoxid.**
- **Not more than 0.75 per cent water-soluble arsenic pentoxid.**
- **Density not less than 80 or more than 100 cubic inches per pound.**

Use only dusting machinery especially constructed for cotton dusting.

Poison only when the air is calm and the plants are moist. In most sections this means making only night applications.

Use about 5 to 7 pounds of calcium arsenate per acre for each application.

Start poisoning when the weevils have punctured from 10 to 15 per cent of the squares.

Keep your cotton thoroughly dusted until the weevils are under control. This usually means about three applications at the rate of one every four days.

Then stop poisoning until the weevils again become abundant.

If the weevils become abundant early enough to injure your young bolls, make one or two more applications late in the season.

If you have a heavy rain within 24 hours after dusting, repeat this application immediately.

Do not expect to eradicate the weevils. Poisoning merely controls them sufficiently to permit a full crop of cotton and you can always find weevils in the successfully poisoned field.

Keep your cotton acreage low and do everything possible to increase your yield per acre, as it costs just as much to poison one-quarter bale per acre cotton as bale per acre cotton.

Always leave an occasional portion of a cut unpoisoned for comparison with the adjoining poisoned tract. This will show how much you have increased your yield by poisoning.

INDIRECT MEANS OF CONTROL.

In addition to the use of poison there are numerous other practices which tend to reduce the weevil injury, some of which are of general value, while others can be used only locally. The following pages list a few of the more important of these measures. Even when poisoning is practiced the most thorough attention should be given to the indirect means of control, since they reduce the amount of poisoning which might be necessary and increase the profit which may be secured.

FALL DESTRUCTION OF INFESTED PLANTS.

One of the most important steps toward reducing the weevil infestation, when it can be practiced, is the destruction of the cotton plants in the early fall, before the weevils have hibernated. To be of the greatest value, however, the plants must be completely destroyed by fire or plowed under deeply before the first killing frost, and this limits the use of this control measure to the districts where conditions are such that the entire cotton crop can be picked in time to permit such an early plant destruction.

For many years preceding the development of the calcium-arsenate method of control, removal of the cotton plants from the field as early as practicable in the fall was advocated by this department as the most important step in controlling the weevil. The purpose of this operation is to destroy as many as possible of the immature forms of the weevil still remaining in bolls and squares. These immature forms, if undisturbed, transform into weevils which live over winter and lay eggs the following spring. Fall destruction of plants likewise eliminates hibernating places of the weevil in the field. (See "Destruction of Weevils in Hibernation.")

GRAZING.

In some districts where it is impossible to practice fall destruction of the plants, somewhat the same results can be accomplished by grazing the field with cattle, sheep, or goats. This is only a local measure, however, since the supply of live stock in regions where the bulk of the cotton crop is produced is insufficient for the purpose. Even where poisoning is practiced fall grazing is still advisable, and no danger need be apprehended of poisoning the stock, since there is rarely sufficient poison on the plants to injure stock, even immediately after application, and, furthermore, a considerable period of time generally elapses between the last poison application of the season and the earliest grazing.

SPROUT AND VOLUNTEER COTTON.

Considerable local difficulty in the control of the boll weevil is experienced in southern Texas, and occasionally in Louisiana, owing to the presence of stumpage or sprout cotton. Sprout plants are sometimes encouraged because they produce a small but very early crop. This may have been defensible before the advent of the boll weevil, but at present the practice is undoubtedly the worst that could possibly be followed. The weevils seek out these large plants in the early spring and produce progeny much earlier than they otherwise could, and these progeny infest the planted cotton at an abnormally early date. Volunteer cotton causes the same results over a considerable portion of the cotton belt. The cottonseed scattered about seed houses and gins and along roadsides frequently produces plants which furnish early season breeding places for the weevil. Needless to say, all such plants should be destroyed.

DESTRUCTION OF WEEVILS IN HIBERNATION.

It is often possible for the farmer to reduce considerably his spring weevil infestation by proper winter clean-up measures around his fields. Since the weevils will hibernate successfully in any trash or rubbish, it is a very good practice to burn over or clean up around the cotton field during the winter, especially the fence rows and ditch banks.

In addition much can be accomplished by the elimination of hibernation quarters. Especially along the more northerly portions of the weevil zone, the most successful hibernation is largely confined to the timbered areas, and as a result serious weevil injury is only experienced in the fields adjoining such timber. Under such conditions it is of the utmost importance to plan all clearing operations so that the open areas for cultivation are consolidated into as large tracts as possible, thus increasing the amount of land which is sufficiently distant from timber to suffer a minimum amount of weevil injury.

LOCATING FIELDS TO AVOID WEEVIL DAMAGE.

Nearly every farmer who has been raising cotton for a few years in the presence of the boll weevil knows that there are certain fields on his place where the weevils always appear first and in greatest numbers. With this information as a basis, it is sometimes possible to reduce the damage by refraining from planting cotton in such fields and planting the more distant fields. This practice, however, is advisable only when no attempt is made to control the weevil by poisoning. These fields adjoining timber where the weevil infestation is heaviest are usually the new lands of the place and are thus the most fertile and capable of producing the best cotton crop if the weevil injury is eliminated. Furthermore, when such fields adjoin hibernation quarters, the weevils concentrate on them instead of scattering over larger areas and they serve to a certain extent as trap crops, making it possible to poison the weevils on these fields and thus prevent their spread over the remainder of the crop.

PROCURING AN EARLY CROP OF COTTON.

The foregoing facts relative to the life history, hibernation, emergence, and multiplication of the weevil show very plainly the importance of producing the cotton crop just as early in the season as possible. In reality the production of cotton in the presence of weevils is nothing more or less than a race between the setting of bolls on the plant and the multiplication of the weevils, and everything possible should be done to aid the cotton plants in winning this race. The following are some of the more important steps which may be taken.

EARLY REMOVAL OF PLANTS AND PREPARATION OF LAND.

The first step in procuring an early crop is the early removal of the plants, so that the land may be plowed during the fall and winter and the seed bed thoroughly prepared. Just how much can be done is of course a problem for the individual farmer to determine and depends largely upon labor and weather conditions, but the importance of a well-prepared, solid seed bed can hardly be overestimated. Furthermore, unfavorable weather conditions shortly before planting often prevent plowing at that time, and early preparation does away with this risk.

USE OF EARLY VARIETIES OF COTTON.

One of the most important steps which have been taken to reduce the weevil damage has been the development and introduction of varieties of cotton which mature their crops earlier in the season than those varieties which were planted before the weevil invasion. The variety to be planted in order to obtain a profitable crop under weevil conditions will depend upon a number of factors as well as on the severity of the infestation. The soil, climate, and other factors must be considered. In many localities it is extremely important to select varieties which are resistant to diseases. The first effect of the boll weevil invasion was to cause the abandonment of longer staple and large-boll varieties of cotton and the adoption of small-boll, early varieties of very short staple cotton, such as King and its derivative Simpkins, etc., in the mistaken belief that only such cottons could be successfully grown under boll-weevil conditions. This resulted in the deterioration of the average quality of the cotton grown in many sections, and, consequently, in loss of market prestige formerly enjoyed. Now, however, numerous varieties of better staple cotton have been developed which mature sufficiently early and produce as well as any of the shorter staple varieties, and these are being rapidly adopted. The Triumph variety is one of the best known for the western portion of the infested territory. Among the others which are well adapted to practically the entire Cotton Belt are Cleveland Big Boll, Cook's Improved, Rowden, Toole, Brown, Lone Star, Trice, Columbia, and Acala. There is believed to be no advantage in growing an extremely early short-staple cotton in preference to cottons of this better type in any section. On the contrary, the shorter staples are more and more being discriminated against in the market.

The long-staple cotton situation is particularly interesting. The Upland long staples, which were cultivated when the weevil arrived, were slow-maturing, nonprolific varieties with a very thin boll wall, and were thus subject to a maximum amount of weevil damage. The weevil soon eliminated practically every one of these varieties, and for some time it appeared that the production of long-staple cotton would be practically prohibited. This situation, however, has been met by the development of several long-staple varieties which are prolific and reasonably early. Among the best known of these are such varieties as Express, Webber, and Meade.

It should be thoroughly understood that the selection of the cotton variety is purely a local proposition, and the farmer is warned against the extensive planting of a new variety (merely because it has done well elsewhere) before he has tried it on a small scale under his own conditions. Whenever possible, seeds should be obtained from local planters who have given attention to varietal selection. Varieties introduced from different sources require several seasons to adjust themselves to new conditions. The use of seed simply because it comes from a northern locality is a practice which frequently has done great injury. The only case in which the introduction of northern seed is justified is where the seed represents a variety which has been improved with reference to early maturity. Even this practice is not to be recommended except as an emergency measure when locally improved seed is not available.

EARLY PLANTING.

Another step to be taken in obtaining an early crop, and fully as important as those that have been mentioned, is early planting. No set rule can be laid down as to the proper date for planting. There is much variation in the seasons. Sometimes it is impossible to place the fields in readiness as early as is desirable, and much of the effect of early planting is lost unless the seed bed is in good condition. Rather than plant abnormally early it would be better to improve the seed bed. It is not recommended that planting be done at dangerously early dates. Of course, it is possible to plant entirely too early, so that the plants become stunted during the early days of their growth, and planting should not be done so early as to have this effect upon the plants.

The following additional remarks about the time of planting are quoted from Farmers' Bulletin 501:

> In addition to the use of early varieties and of cultural methods that favor a rapid development of the crop, it is important to plant early—that is, as early as may be consistent with the fundamental object of avoiding weevil injury by shortening the crop season. The difficulty is to determine when the cotton ought to be planted to secure the best results, for the same date will not be most favorable in different localities or even in the same locality in different seasons. The ideal solution of the problem would be for the members of each cotton-growing community to begin planting at the same date.

FERTILIZERS.

The intelligent use of commercial fertilizers is an important step in the profitable production of cotton under boll-weevil conditions. In the western part of the Cotton Belt seasonal conditions are usually such as to make the use of fertilizers of doubtful value, and in some other areas their use seems to be of minor importance, but outside of these areas commercial fertilizers properly used will both hasten maturity of the cotton and materially increase the yield.

On most soils a fertilizer containing high percentages of quickly available nitrogen and of acid phosphate seems to give best results under boll-weevil conditions. On very sandy land, or soils on which cotton is subject to rust or wilt, some form of potash should also be included in the fertilizer used.

Many successful cotton growers are now convinced by their own experience that, by practicing good cultural methods, and with the use of from 500 to 600 pounds per acre of a fertilizer, composed of one-third nitrate of soda and two-thirds 16 per cent acid phosphate, applied before planting, they can grow profitable crops of cotton in spite of heavy weevil infestation, even without the use of poison or other direct means of weevil control.

The building up of soils by the use of legumes, planted either with corn or solid, is of the greatest importance. Commercial fertilizers if used will in all cases give much greater results on lands made more fertile by this practice or may even be unnecessary.

In the alluvial soils of the Mississippi Valley remarkable results in obtaining increased yields under boll-weevil conditions have followed the growth of cowpeas for a single season. The use of cover crops is also of great importance and worthy of the careful attention of all planters in the infested territory where the practice can be fitted into their plan of operations.

The relation of fertilizers to the determinate growth of the cotton plant should be carefully considered. With certain varieties and certain soils the plants have a decided tendency to cease squaring about the middle or latter part of the season and to mature at that time. This habit has been termed the "determinate growth" of the plant. According to the time it occurs, this may be an advantage or disadvantage in the fight against the weevil. If it occurs too early it is a decided disadvantage, because this cessation of squaring produces a food shortage which causes the weevils to attack the bolls with abnormal severity. Consequently, it is very desirable to have the cotton continue squaring long enough to protect the full crop of bolls to maturity. After the bolls are safe, however, the squares are a liability rather than an asset, since a large number of weevils are produced from them and enter hibernation well prepared for survival. In utilizing fertilizers the farmer should plan to supply his weevils with an abundance of food until his crop of bolls has matured beyond the point of injury and then the sooner his cotton stops squaring the lighter his infestation will be the following season.

SECURING A FULL STAND OF COTTON.

There have been many tests and much discussion regarding the spacing of cotton and its relation to boll-weevil control. The most profitable spacing will doubtless vary somewhat with the season, soil, variety, and other conditions. It has been shown conclusively, however, that the number of plants per acre has a very definite relation to yield, especially under weevil conditions. The general practice has been extremely careless, and poor stands of cotton are too frequently secured. Station tests and practical farm experience have indicated the value of thicker spacing under weevil conditions than had been the rule before. Spacing from 9 to 12 inches in the drill or row with two or more plants to the hill has usually given the highest yields in station tests conducted during the past few years, and it is believed that this spacing may be safely recommended for general use. Width of rows should be no more than necessary for proper and easy cultivation.

CULTIVATION.

During the growing season of the crop the fields should be very carefully cultivated, otherwise most of the benefits of early preparation, early planting, and fertilization may be lost. In case of unavoidably delayed planting the best course to pursue is to cultivate the fields in the most thorough manner possible. Under most conditions the old plantation rule "once a week and one in a row" should be applied. This will not result in the direct destruction of many weevils, but it causes the plants to continue uninterruptedly in their growth. By all means such operations as deep cultivation and cultivation close to the plants, which cause shedding, should be avoided. In many instances a fair crop already set and beyond danger from the weevil has been lost by running the plows so close that the side roots were cut and the plants made to shed practically all the fruit. When this happens during the middle or latter part of the season the weevils will certainly prevent the putting on of any more fruit. The general practice of "laying by," by scraping the middles with a wide sweep, leaves a hard surface which causes loss of moisture and shedding. Where the weevil occurs, every precaution must be taken to avoid shedding, as the insect will prevent the maturity of the later fruit and, moreover, will be forced to attack bolls which otherwise would not be injured.

The value of late cultivation has often been discussed. Prior to the advent of the weevil it was an almost universal custom to "lay by" the cotton crops well before the time when the last bolls were set. This practice has been very largely abandoned, however, owing to dire necessity. The importance of keeping the cotton squaring long enough to protect the bolls until safe from injury has been mentioned, and the best way to accomplish this result is to continue cultivation until fairly late in the season, at least two or three weeks beyond the usual time of "laying by." This is, of course, a somewhat dangerous practice, since it is a critical period in the bolling of the cotton plant, and it is very easy to bring on absolute disaster to the crop by improper cultivation at this time. Consequently, all carelessness at this season should be avoided and the plow should not be run too deeply or too close to the plant, or excessive shedding will result. Careful late shallow cultivation is to be very strongly recommended.

DRAINAGE.

The foregoing paragraphs have dealt largely with the necessity of an early crop and have emphasized the importance of expediting the crop by early preparation of the seed bed, early planting, and frequent cultivation. These operations, however, can only be successfully conducted under conditions of good drainage. It is practically impossible to raise a profitable crop of cotton on poorly drained land. On the other hand, the value of good drainage is everywhere apparent. It makes possible the earlier planting of cotton, early germination, and rapid, frequent cultivation. Furthermore, the ground dries out more rapidly after a rain, which increases the control of the weevil by sunshine.

INEFFECTIVE METHODS OF CONTROL.

The extreme seriousness of the boll-weevil problem has called forth hundreds of suggestions in control. These have included changes in manner of planting, attracting the insects to food plants or lights, soaking the seeds to make the plants distasteful, sprays, machines, chemical fumes, and the planting of various plants supposed to be repellent. In many cases these suggestions have been made without due understanding of the habits of the weevil. In other cases practical features, such as the cost of application, have not been considered. The following paragraphs deal with some of the principal ineffective methods that have been proposed.

LATE PLANTING.

Late planting is foremost among the futile means of control. At various times it has been suggested that late planting, especially if following early fall destruction, would so lengthen the hibernating period that no weevils would survive. Very numerous experiments in the field and in cages have proved that the weevils in considerable numbers are able to survive from any reasonable time of early destruction in the fall to beyond the date in the spring when any return whatever could be expected from planting cotton, even if the weevils were entirely eliminated. In a field experiment in Kerr County, Tex., the plants were removed very thoroughly early in November. Neither stumpage nor volunteer plants were allowed to grow during the winter. No other cotton was planted within 9 miles. On the experimental field, planting was deferred until June 10. In spite of this fact weevils appeared as soon as the plants were up and multiplied so rapidly that the production was not sufficient to warrant picking. Similar experiments under different conditions by the State Crop Pest Commission of Louisiana[3] agree in every way with those of the Bureau of Entomology in Texas.

The habits of the insect explain the failure of late planting. In many cage experiments it has been found that the last emerging weevils in the spring appear well into the month of June. In fact, emergence has taken place as late as the 27th and 28th of June.

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[3] Described in Bulletin 92 of the Louisiana Agricultural Experiment Station, published in 1907.

Without any food whatever the emerging weevils are able to survive for some time. The maximum known survival of any hibernated weevil without any food whatever after emergence was 90 days, and a considerable number lived from 6 to 12 weeks after emergence. This ability to survive without food, together with the late emergence, renders it entirely out of the question to exterminate the boll weevil by late planting. Moreover, a considerable number of volunteer plants, which come from seed scattered accidentally or blown from the bolls during the fall, are always to be found along roads, turn rows, in cotton fields, and elsewhere. These plants, starting early in the spring in such numbers as to be beyond control, would furnish a means for the weevils to subsist to the time of planting, however late it might be. In 1906, for instance, at Dallas, Tex., volunteer plants appeared in the spring at the rate of about 1,000 per acre. An investigation showed that the number of such plants increases to the westward as the climate becomes drier. Nevertheless, numbers of plants were found near Memphis, Tenn., and Vicksburg, Miss., in a region of more than 50 inches of annual precipitation. Similar observations have been made each season since 1906.

WEEVIL AND SQUARE COLLECTION.

The possibility of weevil control by hand picking of the adult in the early spring and of the infested squares later in the season has been thoroughly tested on numerous occasions. Undoubtedly this method is efficient when practiced with sufficient thoroughness, but numerous attempts to carry it out on a practical scale have shown that the labor difficulties are almost always prohibitive. This work is of value only comparatively early in the season, and thus falls at the same period when there is a very heavy demand for the labor for other purposes, and it is generally impossible to collect the weevils or infested squares without neglecting other more important work. Consequently, this procedure is recommended only when the cotton acreage under cultivation is small enough to permit the usual labor on the plantation to do the work without interference with cultivation or other important work. Where square picking is relied upon for weevil control, it should be begun as soon as the first punctured squares are noticed and every effort made to keep all punctured squares picked and destroyed for a period of about 30 days thereafter. It is not believed that it will usually be profitable to continue this work for a longer period.

Many attempts have been made to collect the weevils by means of mechanical devices. Hundreds of such devices have been tested and all are to be condemned. They do not collect an appreciable number of weevils unless they are so violent in the agitation of the cotton plant that they are actually injurious to it.

TRAP ROWS.

The idea of attracting weevils to a few early plants or trap rows has frequently been advanced. Practical experience, however, has shown that the only possibility of success in such a procedure lies in the use of entire fields adjoining hibernation quarters, the fields to be poisoned later (see pp. 18–19). The use of only a few rows as a trap crop has been found to be absolutely valueless.

ATTRACTION TO LIGHTS.

Many insects more or less resembling the boll weevil are attracted to lights. Many attempts have been made to destroy the cotton pest by taking advantage of this supposed habit. The boll weevil, however, is not attracted to lights. Numerous tests have been made in which many thousands of other insects were collected around strong lights in cotton fields, but not a single boll weevil was found, in spite of the fact that there were multitudes of these pests in the fields surrounding the lights.

CHEMICAL TREATMENT OF SEED.

Any money expended by the farmers in attempting to destroy the boll weevil by soaking the planting seed in chemicals in the hope of making the plants that are to grow from them distasteful or poisonous to the insects would be entirely wasted. The same remark applies to the various proposed treatments of the plants or soil with chemicals which are supposed to be taken up by the plants to the detriment of the weevils feeding upon them.

TOPPING OF PLANTS.

The topping of plants is sometimes recommended for fields infested with boll weevils. This practice generally results in more harm than good, since it removes a portion of the plants upon which the weevil is most dependent for food during the latter part of the season, and furthermore practically always produces an exceedingly dense foliage growth which greatly reduces the sun control of the weevil stages and promotes such dangerous diseases as boll-rot.

SWEETENED POISONS.

Many attempts have been made to make poisoned substances attractive to the weevils by introducing sweets and other ingredients. Some known sweets, such as honey, have a slight attraction for the weevil, but not enough to assist in practical control. From recent tests, however, it appears that during the early season when the plant is small, and especially during dry weather, the use of some poisoned sweet mixture exercises a considerable degree of control on the weevil. In some districts many reliable planters claim a very definite benefit from the use of mixtures of calcium arsenate and molasses. In other districts, however, it has been shown quite definitely that the use of the dust application of poison is preferable even during this period.

CONTACT POISONS.

Poisons designed to kill the boll weevil by suffocating them have been proposed. They can not, of course, be effective against the immature weevils within the cotton fruit. Normally, also, the adult weevils are found inside the bracts of squares, where they can not be reached by sprays. Numerous chemicals have been found which, if placed directly on the weevil, will cause immediate death, but this does not mean that these chemicals are of the slightest value when applied in the field. In the first place, they are nearly always exceedingly injurious to the cotton plant, and furthermore, when applied to the plant under field conditions, do not come in contact with the weevils sufficiently to kill any appreciable number. In spite of the numerous chemicals tested, not a single contact poison has been found to have any practical value in field use against the weevil.

REPELLENTS.

In the same way it has been claimed that numerous chemicals, fumigants, etc., have a repellent value against the boll weevil. Almost every conceivable compound has been tested for this action and not a single one has been found which had the slightest repellent action against the weevil.

OTHER PROPOSED REMEDIES.

Many other remedies have been suggested for the weevil. Literally hundreds of these have been carefully investigated, and it has been found that the claims of their advocates were based on faulty observations or careless experiments. It is true that many of them when placed directly on the weevil will cause immediate death, but they are still found valueless when used in the field. The claims made at different times of the repellent power of tobacco, castor-bean plants, and pepper plants against the boll weevil have no foundation whatever. In fact, none of these plants has the least effect in keeping weevils away from cotton.

EFFECT OF METHODS OF CONTROL OF THE BOLL WEEVIL ON THE CONTROL OF OTHER INSECTS.

THE COTTON BOLLWORM.

The most important enemy of cotton in the United States, aside from the recently introduced pink bollworm[4] and the boll weevil, is the bollworm,[5] which has existed in this country for many years and frequently reduces the crop very considerably. Its annual damage to cotton in the United States has been conservatively estimated at more than $8,000,000. This insect is also a very important enemy of corn, tomato, okra, cowpeas, and some other crops. Careful studies of the bollworm were conducted by Dr. A. L. Quaintance, of the Bureau of Entomology, in connection with large-scale field experiments in many localities. The conclusions drawn from this practical work were that the essential steps to be taken in the control of the boll weevil are exactly the ones that should be followed in the warfare against the bollworm. The following is the statement by Doctor Quaintance on this subject:

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[4] *Pectinophora gossypiella* Saund.

[5] *Heliothis obsoleta* Fab.

> The steps in the production of early cotton include the principal recommendations for the growing of cotton in the presence of boll weevils. It is therefore seen that injury from the cotton bollworm and the cotton boll weevil may be best avoided by the adoption of one and the same course of improved farm practice. The spread of the latter species will render imperative the adoption of these methods in profitable cotton culture, and along with this change the ravages of the bollworm during normal seasons should become less and less.

The development of weevil poisoning adds another interesting phase to the question of control of the cotton bollworm. Years ago experiments were conducted which showed that a certain poisoning procedure would control the bollworm, but it was found that the bollworm damage was not sufficiently heavy to justify the expenditure necessary for this poisoning. Since the development of weevil poisoning, however, it is interesting to note that the procedure recommended for the two insects is practically identical; thus satisfactory bollworm control should be secured as a supplementary benefit to be derived from weevil poisoning.

THE COTTON LEAFWORM.

The relation between the cotton leafworm[6] or the so-called "armyworm" and the control of the cotton boll weevil deserves special attention.

Years ago the efforts of entomologists and planters were directed toward some means of destroying the leafworm. The use of Paris green and other poisons was found to be very effective. The complication of the situation since the arrival of the boll weevil has caused a decided change of attitude toward the leafworm. This insect usually does not become abundant until late in the season; and unless the boll weevil is controlled, the cotton plants are not setting any bolls at that time. Consequently, the leafworm does not injure the crop and is really often beneficial, because it removes the food supply of the boll weevils. The use of calcium arsenate to control the boll weevil also prevents leafworm damage; thus such poisoned fields are not subject to injury until boll-weevil poisoning has been stopped. Then, the question of whether or not additional applications should be made to control the leafworm is to be determined entirely on the basis of the young fruit on the plants and the possibility of any of this fruit reaching maturity before frost if protected from damage. Under such conditions poisoning solely for the control of the leafworm is very seldom necessary or advisable.

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[6] *Alabama argillacea* Hübner.

THE COTTON APHIS.

In some districts, it has recently been found that the use of repeated applications of calcium arsenate causes a large increase in the numbers of the cotton aphis, or "lice," and on some occasions they have become sufficiently abundant to injure the crop in both volume and grade. So far, such instances have been localized and sporadic, and it is not possible at this moment to say just how general this condition may become. Investigations are under way to determine the factors involved in this development. Studies are also being conducted to determine means of control for the aphis, and results so far indicate that complete commercial control can be secured by a single application of nicotine dust. So far, there seems little likelihood that this will become necessary except possibly in certain restricted regions.

SUMMARY OF CONTROL MEASURES.

The following is an outline of the practical methods of controlling the boll weevil described in detail in the preceding pages. These methods are based upon extensive study and much field experimentation. They represent practically all that is known about combating the most important enemy of the cotton plant. They form a system composed of several parts. A cotton planter can insure success in proportion to the extent to which he combines the different essential parts.

(1) When possible practice early fall destruction of the cotton plants.

(2) Destroy as many weevils as possible in hibernation by cleaning up and burning over hibernation quarters. Also, clear land whenever possible to consolidate open areas and reduce fields subject to early, heavy infestation.

(3) If you are not poisoning, plant in the fields located in situations where weevil damage will be minimized. If you are poisoning, however, plant your fertile soil adjoining hibernation quarters and concentrate your efforts on thorough control of the weevils in these fields.

(4) Prepare the land early and thoroughly in order to obtain an early crop. This means fall plowing and winter working of the land.

(5) Determine the best distances between the rows and between the plants by experiments on local soils. Once this is determined make every effort to obtain a perfect stand at the desired spacing.

(6) Insure an early crop by timely planting of early maturing varieties and by fertilizing when necessary.

(7) Continue to procure an early crop by careful chopping to a stand and early and frequent cultivation. Do not lose the fruit the plants have set by cultivating too deeply or too close to the rows.

(8) Study the instructions governing poisoning very carefully, and if your conditions seem suitable for profitable work poison the weevils thoroughly with powdered calcium arsenate.

(9) Before attempting to poison, obtain from the Bureau of Entomology full and detailed instructions based on your local conditions.

FLORIDA METHOD OF BOLL-WEEVIL CONTROL.

Recently the Florida Agricultural Experiment Station has published a bulletin, No. 165, dealing with experiments by G. D. Smith, under the direction of Dr. Wilmon Newell. In these experiments, which were conducted in northern Florida, the treated fields averaged 439 pounds of seed cotton per acre; the untreated checks averaged only 164 pounds of seed cotton per acre, or an average increase of 275 pounds of seed cotton per acre in all tests. The average cost of treatment for the entire season was $1.57 per acre.

This new method consists of the removal and destruction of all squares present on the plants at a time when about two squares per plant are present. This operation destroys a large percentage of the weevils and is immediately followed by a thorough dusting to poison the terminal buds, where the remaining weevils are forced to feed.

This announcement is particularly important because it apparently offers a means of controlling the boll weevil on low-yielding land.

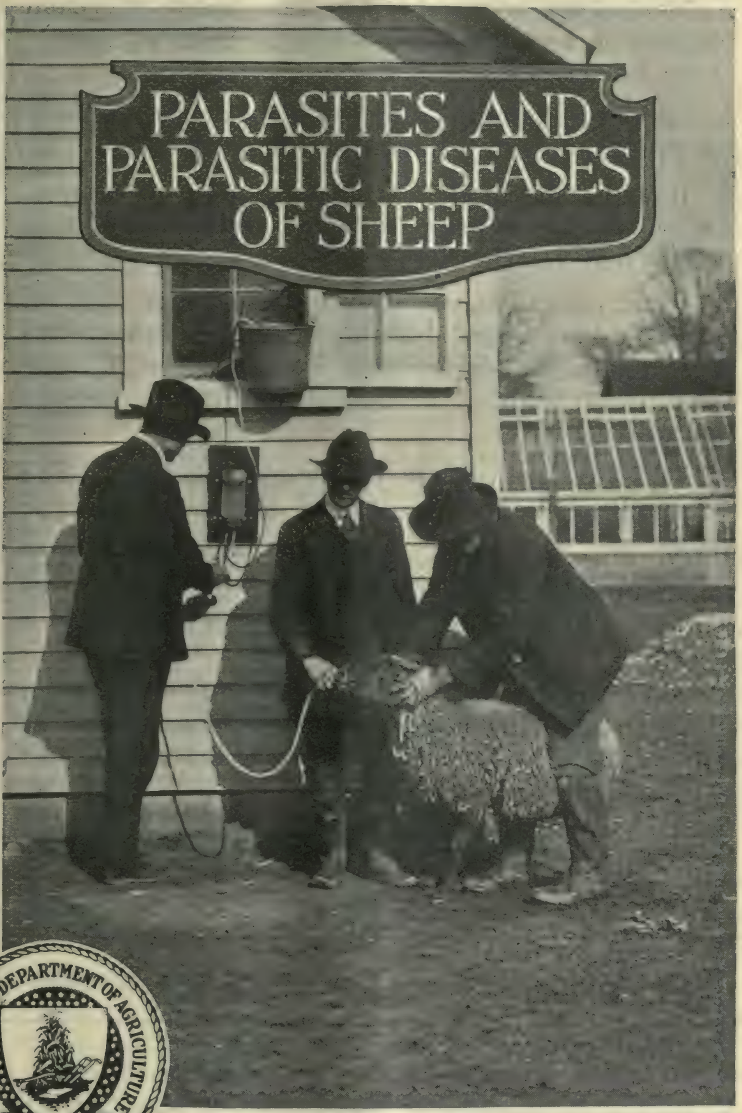
Dr. Wilmon Newell, plant commissioner of Florida, has issued the following note relating to this method:

> The method of boll-weevil control described in this publication (Fla. Sta. Bull. No. 165) has been thoroughly tested in the field in Florida, and is recommended for use of cotton growers of that State alone.
>
> Farmers in other States should not attempt to make use of the control method unless the date of completion of spring emergence of the weevil is definitely known. This information should be secured from your own State entomologist or experiment station, whose advice should be sought before attempting the use of this method of boll-weevil control.

WASHINGTON : GOVERNMENT PRINTING OFFICE : 1923

U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1330



PARASITES AND PARASITIC DISEASES OF SHEEP

SHEEP PROBABLY SUFFER more from parasites than do any other kind of livestock.

Most of our loss in sheep, mutton, and wool is from animal parasites, as sheep suffer comparatively little from bacterial diseases.

Lambs and young animals are most susceptible to parasites and suffer most from them.

It is the sheepman's business to *prevent* disease. When disease is present it is advisable to call in a competent veterinarian.

Pasture rotation, use of forage crops, feeding from racks or bare floors, draining or filling swamps, and restraint of wandering dogs are measures of value in parasite control. *Permanent pastures perpetuate parasites!*

Parasite eggs pass in the manure, usually. The disposal of the manure determines the fate of these eggs.

Parasitized animals usually do not have fever; they are unthrifty. This unthriftiness may have a fatal termination.

Act promptly to ascertain the trouble when sheep become unthrifty. A post-mortem examination of one of the sick animals may disclose the trouble and save the others.

This bulletin is a revision of and supersedes Farmers' Bulletin 1150.

Washington, D. C. Issued April, 1923

PARASITES AND PARASITIC DISEASES OF SHEEP.

MAURICE C. HALL, *Zoological Division, Bureau of Animal Industry.*

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SUSCEPTIBILITY OF SHEEP TO PARASITIC DISEASES.

SHEEP are very liable to attack by parasites, probably suffering more severely from this cause than any other kind of livestock. The importance of parasites and parasitic diseases of sheep is the more evident because of the fact that sheep are but little subject to serious bacterial plagues or virus diseases. In this country sheep rarely have tuberculosis, which is one of the serious conditions in cattle and swine, and among sheep there is nothing comparable to the devastating outbreaks of hog cholera among swine. Occasionally a virulent strain of the bacillus producing lip-and-leg ulcer will spread under favorable conditions and necessitate the treatment of entire flocks, or individual sheep will die of pneumonia or other bacterial diseases, but the steady loss of sheep, mutton, and wool from disease in this country is due mostly to parasites.

The damage from parasites is greatest as a rule among lambs and young animals. The young tissues seem less resistant and more intolerant of injury and the more sensitive nervous system breaks down more quickly under the influence of parasitic injury and poisoning from the excretions and secretions of parasites. It also seems to be fairly well established that in general young animals are more easily infected by parasites than older ones, although very old sheep sometimes appear to acquire an increased susceptibility to infection. Hence it is important in undertaking to prevent infestation with parasites to pay especial attention to the care and handling of lambs and yearlings.

IMPORTANT PREVENTIVE MEASURES.

The use of measures intended to prevent sheep from becoming infested with parasites is especially the function of the sheepman. When sheep become diseased, the niceties of diagnosis and the administration of drugs are well within the province of the veterinarian. Errors in diagnosis by unskilled persons waste valuable time and lead to useless or injurious measures. Drugs intended to kill parasites are from the nature of things usually very potent, and are commonly poisonous substances capable of doing much damage in the hands of unskilled or careless persons; therefore, it is usually advisable to secure the services of a competent veterinarian whenever there is an outbreak of disease and a good veterinarian is available. In places where there are no qualified veterinarians available, the farmer or stockman must use his own judgment in determining whether he can recognize the trouble and administer the remedy.

One of the most important preventive measures in keeping flocks free from parasites is based on the fact that many of the sheep parasites live in the digestive tract of the sheep or in organs in communication with the digestive tract, so that the eggs or young worms pass out in the manure and thus infect the pastures. The fact that sheep manure carries worm infestation is the basis of such preventive measures as pasture rotation, rotation of different kinds of stock on the same pasture, feeding from racks or board floors, use of bare lots for nursing lambs, etc.

Another important preventive measure is based on the fact that many parasites which do not get back to the sheep from a pasture infected with sheep manure are carried back to the sheep by dogs. The fact that the dog which feeds on uncooked sheep meat or viscera may become infested with worms that produce eggs which pass out on to the pastures and may then infect the sheep, is the reason for keeping sheep dogs and other dogs on the farm free from worms and related parasites and for insisting that stray dogs must not wander over pastures and fields under penalty of being shot. Another preventive measure is based on the fact that diseases like scab are transmitted by contact with infected animals and places, and clean flocks must be protected from unsafe contacts.

In a general way, the presence of parasites may be suspected as the cause of disease where there is little or no fever, the animals losing condition and becoming thin and commonly having a diarrhea or being constipated. Other features may be associated with certain parasites. Bloodsucking parasites produce anemia, the blood becoming thin and pale as a result of having too few red blood corpuscles for the amount of serum present. Often there is associated with this an edema, in which fluid accumulates in the pendant or lower portions of the body; this is especially prominent in stomach-worm infestation in sheep, the fluid accumulating under the lower jaw and giving rise to the so-called "bottle jaw."

In this connection, the advisability of finding out promptly the cause of the trouble when sheep become diseased should be emphasized. Curtice has stated the case as follows:

> The sheep owner who discovers weakness among his lambs should not wait until one of them dies before he endeavors to make a diagnosis, but should undertake to diagnose the disease in the earlier stages by sacrificing one or more of the worst affected, and thus gain time in treating and preventing the extension of the disease. By waiting for the disease to develop he allows the lambs to grow poorer and weaker, and when action is finally undertaken it is upon patients which are, in many cases, already too weak to stand vigorous treatment and which in no way profit by preventive measures as they should.

EXTERNAL PARASITES.

External parasites are those which live on the exterior of another animal called the host animal, that is, on the skin or in the layers of the skin or in the hair follicles. Internal parasites are those which live in the body tissues or cavities of the animal that serves as a host.

The external parasites of sheep are all arthropods, or animals having 6 or more legs, some of them being insects, which have 6 legs in the adult stage, others, such as mites and ticks, being more closely related to the spiders and possessing 8 legs in the adult stage. Some of these parasites spend their lives on the sheep; this is true of the scab mites and the lice. These are the important forms. Others, such as various kinds of biting flies, attack sheep occasionally but spend much of their lives off the sheep.

LICE.[1]

Location.—Lice live on the skin of sheep, crawling about on the wool or hair from place to place and clinging to the wool fibers or hairs in feeding. The sucking body louse (*Hæmatopinus ovillus*) is commonly found in colonies on various parts of the body, including the face. The foot louse (*Linognathus pedalis*) is usually found on the lower portions of the legs, below the true wool and in the short, coarse hair. The biting louse (*Trichodectes ovis*) occurs on various parts of the body.

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[1] *Hæmatopinus ovillus, Linognathus pedalis, Trichodectes ovis* (=*Tr. sphærocephalus*).

Appearance.—The sucking body louse has a head somewhat longer than the thorax (fig. 1). The abdominal segments bear two rows of long hairs. The male is 2.1 millimeters (about one-twelfth of an inch) long and the female is 2.8 mm. (about one-tenth of an inch) long. There is an inconspicuous eye on each side of the head. The wool in the region attacked by this louse is usually discolored and contains numerous brown particles, the fecal deposits of the lice.

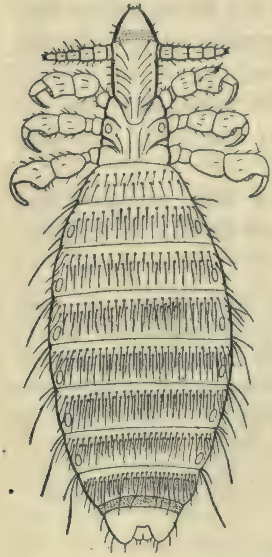

FIG. 1.—Sucking body louse (*Hæmatopinus ovillus*). Female, back view. Highly magnified. (From Neumann, 1907.)

The foot louse has a short head, as wide as it is long, which merges into the thorax, with reddish oblique bands on each side (fig. 2). No eyes are present. The abdominal segments bear two rows of hairs, of which those at the lateral margin are longer than the others. The female is 2.2 mm. (about one-twelfth of an inch) long and 1 mm. (one-twenty-fifth of an inch) wide; the male is broader and flatter. This is a sucking louse like the preceding species.

The biting louse has a head that is wider than long, with a broad, round anterior end (fig. 3). The abdominal segments show a median dark line and have only a single row of hairs. The male is 1.4 mm. (about one-twentieth of an inch) long and the female is 1.6 mm. long.

Life history.—The eggs of the various species of sheep lice are attached to the hair or wool in the sites customarily infested by the adult lice. The eggs of the sucking lice are said to hatch in 10 to 18 days; those of the biting lice in 5 to 8 days ordinarily, or 10 days in cold weather. Available evidence indicates that the young lice become mature and begin laying eggs in the course of about two weeks after hatching. The sucking lice, as the name implies, are bloodsuckers. The biting lice feed on the epithelial scales and other material on the surface of the skin. Lice usually cause little trouble in summer, but become more numerous and annoying in winter.

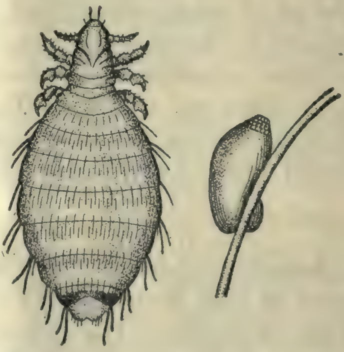

FIG. 2.—Sheep foot louse (*Linognathus pedalis*). Adult female and egg, enlarged. (From Osborn, 1896.)

Distribution.—Biting lice are rather common in the United States. The sucking body louse is fairly common on sheep in the Southwest. The foot louse has been found on sheep in various parts of the country.

Symptoms and lesions.—Lice, whether biting lice or sucking lice, cause itching and irritation. This of itself interferes with nutrition, and affected animals fail to fatten or keep in condition as they should. Moreover, the itching leads to scratching, with a resultant loss of wool, and this scratching adds more time lost from feeding to that lost from discomfort. Scratching may also cause cuts and bruises. The loss of nervous energy and the interference with feeding and nutrition tend to stunt the growth of young animals, interfere with the fattening of the entire flock, and predispose to other diseases by lowering the vitality. Actual lesions in the form of sores are caused where numerous biting lice cluster. The sucking lice abstract blood and lymph in considerable quantities where the lice are numerous. Finally, the excreta of the lice soil the wool, sometimes to a considerable extent; this is particularly true of the sucking body louse.

Lice are readily found on infested animals by examining them carefully, preferably in direct sunlight.

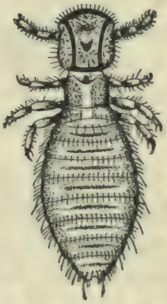

FIG. 3.—Sheep louse (*Trichodectes ovis*). Adult female, enlarged. (After Neumann, 1892.)

Treatment.—Where sheep are infested with biting lice only, sodium fluorid may be applied in the form of a powder to get rid of them, a single application sufficing for this purpose. The powder is rubbed into the skin at a number of places so as to insure a good distribution. It is of no value against sucking lice. Sodium fluorid should not be applied to mucous membranes, such as those of the mouth and anus.

For sucking lice it is necessary to use a contact poison, and these poisons are also satisfactory for biting lice. In cold weather, where dipping is inadvisable, insect powders, composed largely of pyrethrum and naphthalene, may be used as a control measure and will serve to control the lice, but are not satisfactory in eradicating them.

For dipping, the substances which have been found effective in field tests are coal-tar creosote, cresol, arsenical dip, and 0.07 per cent nicotin solution with 2 per cent flowers of sulphur. To eradicate lice it is usually necessary to dip at least twice, with an interval of 14 to 16 days between dippings, in order to kill the lice that hatch out after dipping, since these dips can not be depended upon to kill all the eggs or "nits." Spraying is generally unsatisfactory as a method of applying dips to sheep, as it is too difficult to wet the wool.

Sheep should be handled carefully, not roughly. Dip the bucks, ewes, and lambs separately. The sheep should be fed and watered from 3 to 6 hours before dipping, in order that they may not be hungry or thirsty and yet not gorged with food. In hot weather they should be cooled off before dipping, and when the nights are cold they should be dipped in time to dry off before night. Ten days should elapse after shearing before dipping, in order that cuts may heal, especially when arsenical dips are used. Because of their extremely poisonous nature it is usually inadvisable to use arsenical dips in treating sheep.

Prevention.—To prevent infestation with lice it is essential that contact with lousy animals be prevented and that animals free from lice be kept out of sheds, pens, inclosures, or pastures where lousy stock has been present within three weeks. After the first dipping, sheep should be put on clean pastures or held in clean inclosures to allow time for any eggs to hatch and the lice to die, or else the sheds and lots should be thoroughly cleaned out and disinfected before using them. For this sort of disinfection the coal-tar dips in double the strength used for dipping are satisfactory.

THE SHEEP TICK.[2]

Location.—The sheep tick occurs in the wool and on the skin.

Appearance.—The sheep tick is not really a tick, but is a kind of wingless fly (fig. 4). It has 6 legs, whereas the full-grown true ticks have 8 legs. The mouth parts are very similar to those of other flies. These insects are reddish or gray-brown in color, and are about a quarter of an inch long on an average, and may therefore be easily distinguished from the lice. They are distinctly divided into head, thorax, and abdomen, which distinguishes them from the true ticks, which are occasionally found on sheep, as these true ticks have the thorax and abdomen fused. with the head not conspicuously distinct.

Life history.—The egg of the sheep tick is not laid as such, but is retained in the body of the female until it develops into a larva or pupa, which occurs in about seven days. The pupa is then deposited by the tick and is attached to the wool of the sheep by a gluelike substance. When deposited it is covered with a soft, white membrane, which becomes brown and hard in about 12 hours. The pupæ of the sheep tick are commonly called eggs. The young ticks emerge from the pupal stage in 19 to 24 days, the shorter time being in warm weather and the longer in cold weather. The tick is almost full-grown when it leaves the pupal case and it becomes mature in 3 to 4 days. After copulation the female may deposit its first pupa in 8 to 10 days.

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[2] *Melophagus ovinus*. For additional information see Farmers' Bulletin 798 on "The Sheep Tick."

Distribution.—Sheep ticks are widely distributed over the world and are common in the United States on both farms and ranges. Where dipping of range sheep for scab has been practiced it has kept down the sheep tick, but where it has ceased sheep ticks have become very prevalent. They are most common on coarse-wool and medium-wool sheep, and prefer the neck, breast, shoulders, belly, and thighs.

Symptoms and lesions.—The damage done by the sheep tick is of two kinds. It is a bloodsucker, thus causing great irritation, loss of blood, interference with feeding, and consequently poor nutrition and reduced vitality. It lives in the wool and lowers the value of the wool by soiling it with the excreta and with the pupal cases. The loss caused is in addition to the wool deterioration which results from the injury to the sheep itself. The ticks may be easily found on parting the wool. Their presence may be suspected when sheep bite, scratch, or rub, and show a ragged fleece as a result.

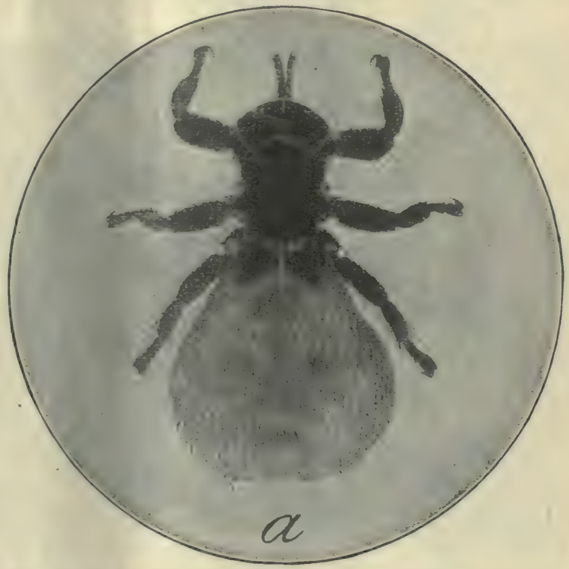

FIG. 4.—Sheep tick (*Melophagus ovinus*). Engorged female, enlarged. (From Imes, 1917.)

Treatment.—The treatment for ticks is dipping. The coal-tar creosote, cresol, nicotin, and the lime-sulphur-arsenic dips are all satisfactory, but dips containing arsenic are not desirable for sheep. Dip twice at a 24- to 28-day interval.

Prevention.—All places which have been occupied by ticky sheep should be regarded as dangerous from this standpoint for a period of two months, as the pupæ may retain their vitality under certain conditions for almost this length of time. Usually pupæ remain in the wool, but wool containing pupæ may be rubbed off or pulled off and young ticks hatching from such pupæ may afterwards get on sheep. If inclosures are to be used for clean sheep within this period they should be thoroughly cleaned and the litter and manure disposed of in such a way that sheep can not come into contact with them until after the lapse of the 60-day period. A strong solution of coal-tar dip should also be used, but this can not be depended on to kill the pupæ, though it is useful in killing the ticks that might escape a cleaning process. To disinfect stone or wire-fence corrals, brush or straw may be scattered over the surface of the ground and burned. Clean sheep must be kept away from contact with ticky sheep and care must be taken to see that goats or other animals do not convey ticks to the sheep. Even persons may occasionally carry ticks for a short time in their clothing, and this must be kept in mind at shearing time and whenever there is danger of infection from persons who travel from one flock of sheep to another.

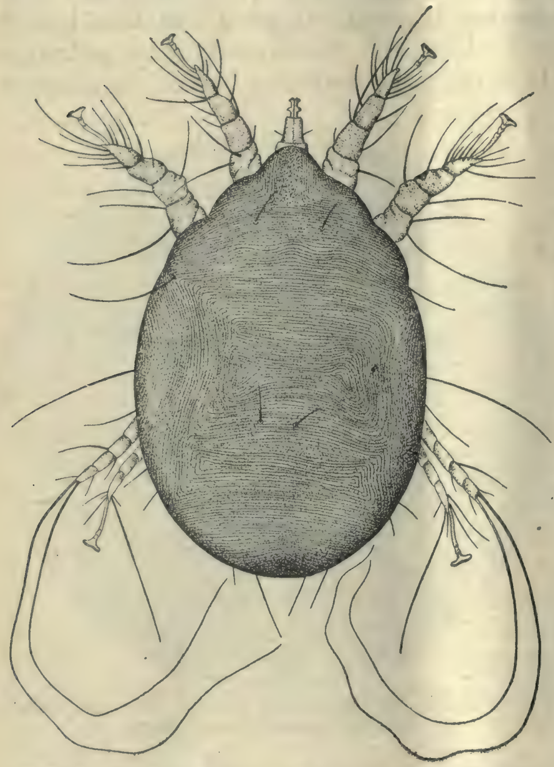

FIG. 5.—Sheep-scab mite (*Psoroptes communis ovis*). Female. Back view, greatly enlarged. (After Salmon and Stiles, 1898.)

SHEEP-SCAB MITE.[3]

Location.—On the skin.

Appearance.—These parasites are very small animals, commonly called scab mites (fig. 5). The male is only 0.5 mm. (one-fiftieth of an inch) long and the female 0.625 mm. (one-fortieth of an inch), but they may be seen with the naked eye as small white objects, especially when placed on a dark background. It is easier to see them when they are warmed, by sunlight or otherwise, on such a background, as they may then be seen in motion. The full-grown mites have 4 pairs of legs and these legs have long hairs. In the female there is a so-called sucker on a jointed stalk on the tip of the first, second, and fourth pairs of legs, and in the male on the first, second, and third, the fourth pair in the male having a sucker which is not on a jointed stalk.

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[3] *Psoroptes communis ovis.* For additional information see Farmers' Bulletin 713 on "Sheep Scab."

Life history.—The female mite usually deposits at least 15 eggs during her life, and may deposit 24. In 3 or 4 days these hatch, the young mites beginning life with only 6 legs. In 7 or 8 days these have become 8-legged mites, which mate and begin depositing eggs in the course of the next 3 or 4 days. One investigator (Gerlach) has estimated that in 90 days this rate of reproduction under favorable circumstances, beginning with a single impregnated female, would produce one and one-half million mites.

Distribution.—Scab was formerly widely distributed over the United States, being the greatest pest that sheepmen had to contend with. Quarantine and eradicative dippings have nearly cleaned it out of the greater part of this country, so that at present it is largely a matter of cleaning up the relatively small amount that is scattered about, an exceedingly difficult task, however, because of the scattered condition of the infection. The cooperation of individual owners in promptly reporting to local livestock sanitary authorities cases of scab or cases suggestive of scab is highly important in scab eradication.

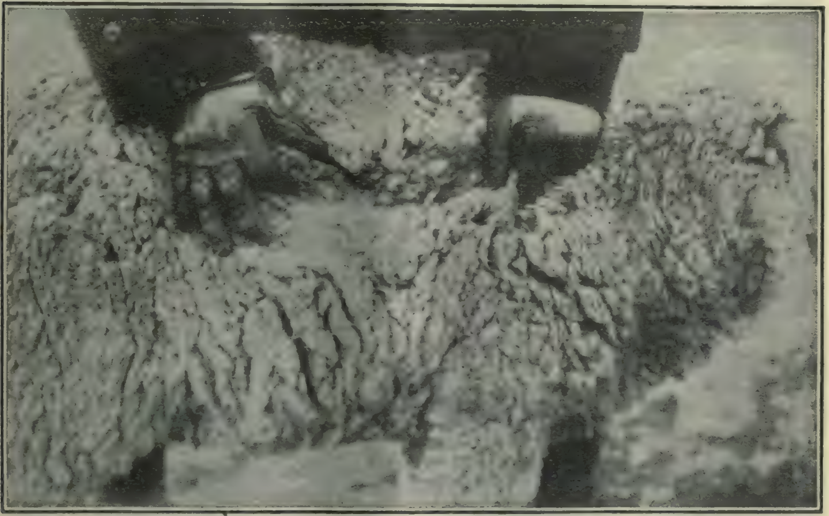

FIG. 6.—Characteristic scab lesion in early stages of the disease. (From Imes, 1916.)

Symptoms and lesions.—The scab mite pricks the skin and sucks the blood serum. The puncture becomes inflamed, forming a small red spot with a slight exudation of serum. This serum forms the scab, from which the disease takes its name (fig. 6). The watery part of the serum dries out, leaving a small crust for each bite, the total aggregate of these bites leading to the formation of considerable crusts or scabs. At the same time the bite of the mite causes itching, and this in turn leads to scratching, rubbing, and biting, thereby adding to the initial inflammation and producing a certain amount of hemorrhage as the scabs are rubbed off and sores form. The serum and sores afford lodging and favorable conditions for bacteria and become infected. The skin reacts to the continued inflammation and becomes thickened.

The first symptom noticed as a rule is the itching, manifested by a disposition to rub and scratch. The wool is roughened and broken by the scratching, and this condition suggests the possibility of scab. The sheep become restless and spend considerable time biting and rubbing the affected spots, finally losing the wool off large areas and leaving scabby sores (fig. 7). The time and energy spent in trying to alleviate itching is time and energy lost from feeding and growing, and this fact shows itself in the poor condition of scabby sheep. Ultimately many of these sheep will die unless treated and they are always so weakened as readily to fall victims to other diseases.

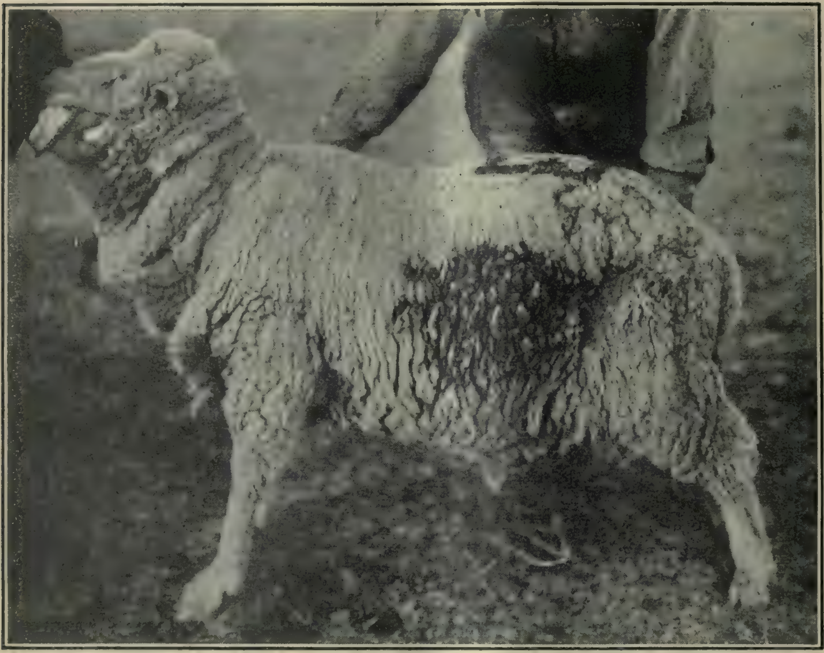

FIG. 7.—Scabby buck with entire hind quarters and flank affected. (From Imes, 1916.) (The discolored area is due to dip stain from hand dressing.)

The diagnosis of this disease is best made by a capable veterinarian, as the disease is too serious to warrant taking any chance on its spread. Itching, loss of wool, and other conditions present in scab may also be shown in the presence of lice, sheep ticks, true ticks, bearded seeds, cactus spines, eczema, wildfire, summer sores, rain rot, shear cuts, sunburn, and inflammation of the sebaceous glands; the effects of alkali dust may at times be mistaken for scab.

Treatment.—The only satisfactory treatment for scab is dipping. Hand dressing will not suffice and permits the spread of the disease while seeming to cure obviously affected areas. Animals must be dipped twice at intervals of 10 to 14 days, preferably 10, in warm dip. Ewes, bucks, and lambs should be dipped separately. Sheep must be held in the dip not less than two minutes; in the case of animals with advanced cases, especially in the fine-wool sheep, they should be held three to five minutes the first time, unless the crusts and scabs are first broken up and soaked with dip. The lime-sulphur dip and the nicotin-and-sulphur dip are the two dips recognized in official dipping for scabies. Protection from reinfection appears to be afforded for 33 days by the lime-sulphur dip and for 69 days by the nicotin-and-sulphur dip.

Prevention.—Open pasture that has been used by scabby sheep should be regarded as dangerous for a month or two, and buildings are regarded as suspicious for a year or more. Keep sheep away from old bedding grounds and other infected areas. As regards buildings, pens, etc., it is advisable to abandon them, burn them, or else clean and disinfect thoroughly if they are to be used after having had scabby sheep in them. Stray sheep should be looked on with suspicion and goats may carry scab mites for long periods. Care must be used in purchasing sheep from areas where there has been any scab.

OTHER VARIETIES OF SCAB.

Head scab and foot scab in sheep are relatively rare diseases caused by species of mites different from those causing common scab. The same methods of treatment may be used, but head scab may prove more difficult to cure and four or five or more dippings, supplemented by local applications of remedies, may be necessary. In cases of head scab the interval between dippings should be shortened to a week or even to five days.

OTHER EXTERNAL PARASITES.

True ticks occasionally infest sheep, but in this country it is rare to find ticks present on sheep and we are fortunately free from ticks that habitually infest sheep. Among those that do occur on our sheep is the spinose ear tick.[4] This is particularly prevalent in the Southwest. It enters the external canal of the ear and attaches there well below the hair line, sucking blood from the tender skin. The ticks enter the ear as 6-legged seed ticks, become engorged, grub-like larvæ, molt to form the 8-legged nymph, which is covered with numerous small spines, and after months spent in the ear the nymphs

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[4] *Otobius mégnini* (*Ornithodoros mégnini*). For additional information see Farmers' Bulletin 980 on "The Spinose Ear Tick and Methods of Treating Infested Animals."

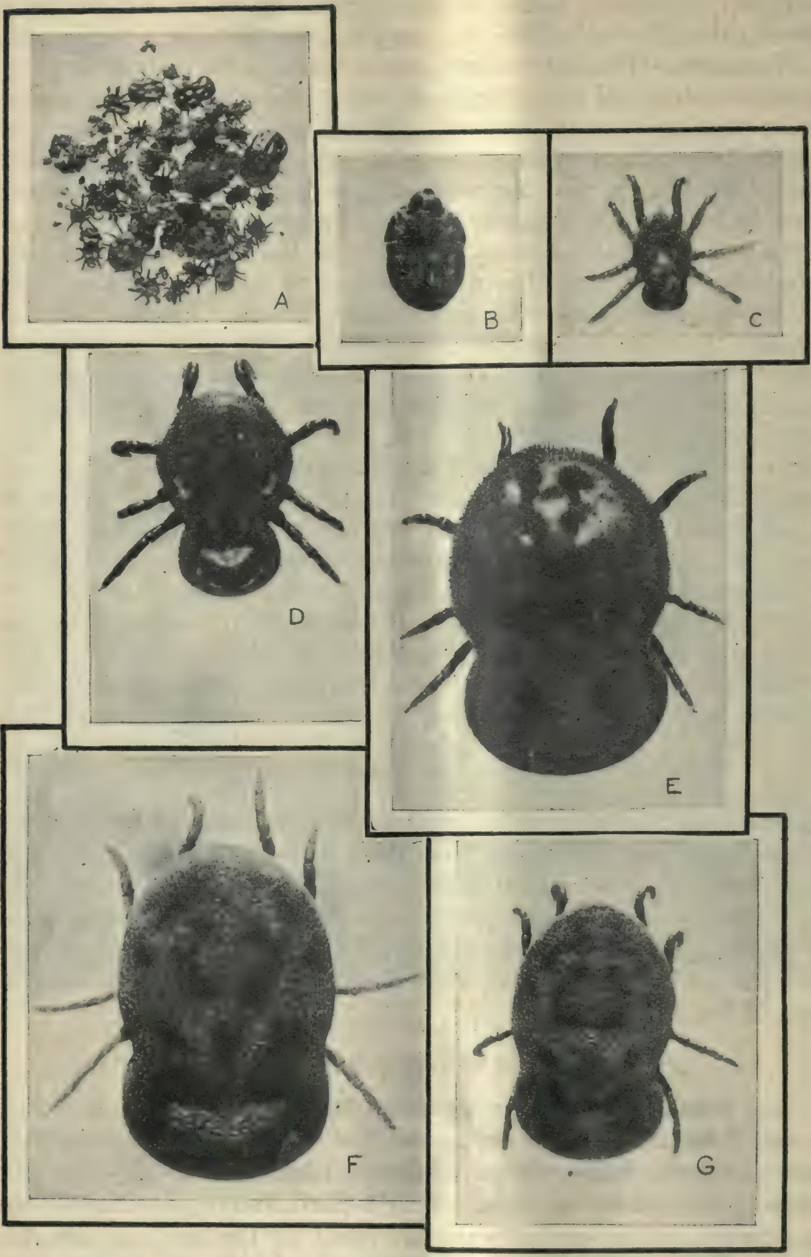

FIG. 8.—The spinose ear tick (*Otobius mégnini*). *A*, ear ticks and débris from ear of cow (about natural size). *B*, engorged larva (magnified five times). *C*, young tick (magnified five times). *D*, partially engorged young tick (magnified five times). *E*, fully engorged young tick (magnified five times) *F*, adult female (magnified five times). *G*, adult male (magnified five times). (From Imes, 1918.)

crawl out, conceal themselves in dry protected places, transform into adult ticks, and mate (fig. 8). The female lays eggs which give rise to the 6-legged seed ticks and these in turn infest new hosts. Infested animals often have the ear canal plugged with wax and the excretions of the ticks. Such animals shake their heads or turn them from side to side. The ticks cause serious injury and occasionally death, especially among horses and cattle. The best treatment is to clean the ear canal with a wire loop, using care not to injure the animal, and inject into the canal a mixture of 2 parts commercial pine tar and 1 part cottonseed oil.

The screw worm[5] is the name commonly given to the maggot of a sort of blowfly especially prevalent in the Southwest. It is especially apt to infest sheep recently sheared, getting into the fresh cuts, and in the same way attacks sheep and other animals that have been recently castrated, dehorned, or otherwise injured by having the skin broken. The fly is larger than the housefly (fig. 9), dark bluish-green in color, with three black stripes on the back between the wings, and with a red or reddish-yellow coloring in the face. It deposits its eggs in carcasses or in wounds, in masses of from 40 to 250 eggs. In wounds these eggs hatch in three hours or less, giving rise to young maggots which burrow into the wound and grow rapidly during a period of 4 or 5 days (fig. 10). They then leave the wound, burrow into the ground and form pupæ. The adult fly emerges from the pupal case in 3 to 14 days, the entire life cycle being 1 to 4 weeks.

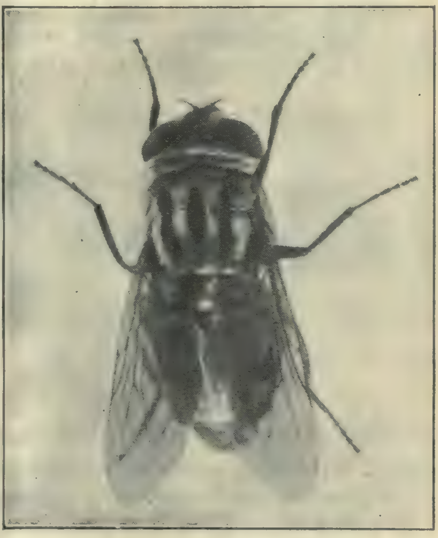

FIG. 9.—Screw-worm fly, as seen from above. Much enlarged. (From Bishopp, Mitchell, and Parman, 1917.)

The best treatment for an infested wound is to pour in chloroform, later remove the maggots, wash with a suitable disinfectant, and apply pine tar to prevent fresh attacks. Probing and opening the burrows is regarded as inadvisable. When the wound is severe it is advisable to call in a veterinarian, as there is sometimes serious danger from hemorrhage and infection. Every year numerous animals die from screw-worm infestation.

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[5] *Cochliomyia macellaria* (*Chrysomyia macellaria*). For additional information see Farmers' Bulletin 857 on "Screw-Worms and Other Maggots Affecting Animals."

By way of prevention it is essential that carcasses of animals dying from any cause should be promptly burned or otherwise disposed of so that flies can not breed in them. If they are buried they should be buried in quicklime and the entire carcass should be at least two feet under ground and the soil tightly packed. Shearing cuts and other injuries from accident or operations should be coated with pine tar to prevent flyblow. Flytraps are valuable as control measures.

Sheep-wool maggots belonging to a number of species[6] are somewhat similar in habits to the screw-worm fly. Related flies have become a very serious pest to sheep in Australia. The flies deposit their eggs or young in the wool. Infested sheep are sometimes treated by clipping the wool about infested parts and applying concentrated dip, chloroform, or mixtures of turpentine and tar. It is also advised that lambing should occur as early as possible and shearing be carried on before the warm weather sets in, to reduce the chance of infestation. The wool of sheep, especially those affected with diarrhea, should be kept trimmed about the tail region to prevent flyblow at this place. A practice which has been found of considerable value in Australia consists in spraying the tail region of the sheep with 0.7 per cent solution of arsenious oxid just before lambing time. This can be done quickly and easily, is cheap, and affords considerable protection. The prompt destruction of carcasses is as important in the control of these maggots as it is in the control of the screw worm.

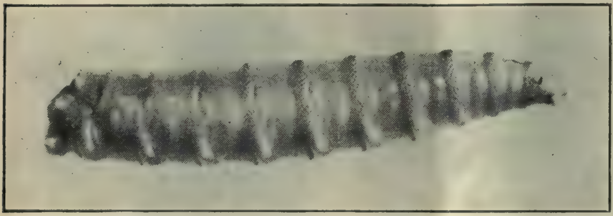

FIG. 10.—Screw-worm maggot, side view. Enlarged. (From Bishopp, Mitchell, and Parman, 1917.)

INTERNAL PARASITES.

The internal parasites include tapeworms, flukes, roundworms, and a few other forms, such as the maggots causing grub in the head, the tongue worm, and the one-celled forms, or Protozoa, these last being microscopic in size and of comparatively little known importance in the United States so far as sheep are concerned.

The following discussion includes the more important of the numerous kinds of internal parasites that infest sheep.

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[6] *Phormia regina, Lucilia sericata,* and others.

ARTHROPODS.

The arthropods include certain forms that live during a portion of their life as internal parasites of sheep, though most of the arthropod parasites of sheep are external parasites.

The arthropods are forms which possess 6 or more leglike appendages, such as the insects, which, in a limited sense of the word, include those forms with 6 legs, the spiders and spiderlike forms, which as adults have 8 legs, and other forms having more than 8 legs, some of them having a considerable number.

The life history of the arthropods varies so greatly in the case of different forms that it is hardly possible to give a general statement covering it.

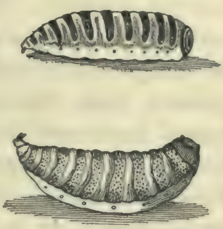

FIG. 11.—Grub in the head (*Œstrus ovis*). Above, normal position; below, grub turned on its back. (From Osborn, 1896, after Riley.)

GRUB IN THE HEAD.[7]

Location.—The grubs occur in the nostrils and in such communicating cavities as the frontal sinus and the maxillary sinuses, cavities in the upper jawbone.

Appearance.—The parasites appear as maggots which at first are less than 2 mm. (one-twelfth of an inch) long. When fully developed in the sheep, they are usually over 2 cm. (four-fifths of an inch) long and 7 mm. (almost one-third of an inch) wide, though the grub may contract or expand to a smaller or greater dimension. There are 11 segments, rather flattened on the ventral (lower) surface and arched on the dorsal (upper) surface. The ventral surface is spiny, the dorsal smooth. At first the grubs are white, later they become yellowish and darker, a band appearing on the dorsal side of the segments and finally becoming black (fig. 11). At the head end are two large hooks and at the tail end are two rounded breathing pores.

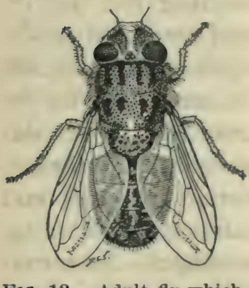

FIG. 12.—Adult fly which causes grub in the head (*Œstrus ovis*). Enlarged. (From Bau.)

Life history.—The adult fly (fig. 12), which looks something like an overgrown housefly, is active during the summer, usually in June and July. The female fly deposits a tiny grub on the edge of the sheep's nostril. Sheep usually run when the fly attacks them or is seen by them, often becoming frantic and holding the nose in the dust or against other sheep. The attack occurs usually during the heat of the day, the fly being quiet in the early morning and late afternoon. The grub migrates up the nostrils by means of its hooks and spines, and may make its way to the communicating cavities. Occasional grubs fail to leave the sinuses in time and become too large to get through the apertures they entered; these die and usually become calcified. The grub in the sinuses feeds and grows until it is ready to leave the sheep. Sometime during the spring or summer, in temperate climates, the grubs leave the sheep and fall to the ground, into which they burrow a short distance. Their skin becomes hard and leathery and they lie quiescent for three weeks to two months, according to conditions of temperature and moisture. Finally the adult flies break out from the leathery envelopes within which they have undergone their transformation from the preceding stage, like a butterfly in a chrysalis, crawl to the surface, and are ready to mate and then to deposit their young.

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[7] *Œstrus ovis.*

Distribution.—This parasite appears to be prevalent throughout the United States wherever sheep are kept. It is a common and troublesome pest, especially in the South.

Symptoms and lesions.—As the grub crawls about in the nostrils the hooks and spines set up an irritation which is at first acute with a resultant flow of serum from the nose, resembling a "cold in the head." Presently the nostrils show evidence of bacterial infection, the flow thickens and becomes discolored, presenting the picture called by the sheepmen "snotty nose," a pronounced catarrhal condition. The hooks and spines set up minute hemorrhages, which are visible on post-mortem examination as rows of blackened dots on the mucous lining of the nostrils and sinuses. One result of this irritation and inflammation is a thickening of the mucous membrane, a condition which interferes with its normal function of smell and helps to close the breathing passages, which are already functioning improperly as a result of the thick, catarrhal secretions. As a consequence the sheep experiences difficulty in breathing, which tends to impair its general physical condition. Add to this the fact that the sinuses may become filled with purulent matter and that the toxins from the purulent matter here and elsewhere are constantly absorbed and there is evidently present a condition which must weaken an animal. Furthermore, the irritation due to the wandering of these spiny grubs over the sensitive mucous membrane of the nostrils prevents the sheep from resting or devoting its full time and energy to feeding and growing.

Though the characteristic symptom of grub in the head is the profuse discharge from the nose, the sheep show other evidences of the infection. They sneeze frequently and often show symptoms of difficult breathing. The eyes become inflamed, as would be expected in connection with an inflammation of the nostrils, the head is often carried low or may be moved about in a peculiar manner as though the sheep were trying to rid themselves of an obstruction in the head, the appetite is diminished, or at least the sheep eat less owing to distraction from pain and difficult breathing, and in severe cases the animals may have convulsions and ultimately die.

Treatment.—The treatment for this condition is not very satisfactory and dependence should be placed on preventive measures, which are, fortunately, of a comparatively simple sort and easily applied. One of the measures which has been advocated in the way of treatment is to put the sheep in an inclosure on hard ground or on a floor of some sort which has been sprinkled with lime, and to mill them around so as to stir up the lime and cause violent sneezing, in the hope of expelling the grubs in this manner. This may remove some grubs from their position in the nostrils, but it can have no effect on those in the sinuses and will by no means remove all those in the nostrils. Attempts have been made to kill or remove grubs by putting the sheep in a room with burning sulphur, some person remaining there as long as possible to test the strength of the fumes. This is dangerous to the sheep and the operator and can not be recommended, especially since it is not very successful. In the case of particularly valuable animals which are seriously affected, the sinuses may be opened with a trephine and the grubs extracted with forceps. Sheep tolerate the operation well enough, but the operation is one that is suitable only for trained and skilled operators and should be done by a competent veterinarian. If the sheep is not worth the cost of such an operation, it should be sent to the butcher before the progress of the disease has rendered the animal unfit for food.

Prevention.—Smearing the nose of the sheep with a preparation that will prevent the fly from depositing its larvæ successfully on the nostril has been found to be a very satisfactory preventive measure and is one that is extensively practiced. Various preparations have been used, such as equal parts of tar and grease, of tar and fish oil, or of tar and whale oil; but the use of pine tar alone seems to be quite satisfactory. It is advisable to apply the tar by hand, at least the first time, and to make sure that it is applied liberally to the entire margins of the nostrils. The application may be renewed by hand later, as often as necessary, or may be automatically renewed by using a salt lick consisting of a thick plank or split log in which holes, 2 inches in diameter, are bored, with salt placed in the holes and the edges of the holes heavily tarred, so that the sheep get the tar on their nostrils as they lick the salt.

TAPEWORMS.

Adult tapeworms are usually composed of a head, armed with hooks and suckers as a rule (though those in the sheep's intestines have no hooks), and a body consisting of a number of flat segments arranged in a chain. Adult tapeworms are usually found in the small intestines, but in some cases they may occur in the stomach, large intestines, or the ducts of the liver and pancreas. Tapeworms produce eggs of microscopic size which pass out in the feces and which on being swallowed by a suitable host, usually of a sort different from the host of the adult tapeworm, give rise to an intermediate stage, or larva, which is usually more or less spherical or elliptical and composed of a tapeworm head and neck attached to a membrane, the membrane usually inclosing a clear fluid. In the case of many of the common tapeworms this form is called a bladderworm. It usually occurs in the body tissues, and when these are eaten by the host of the adult tapeworm the head of the tapeworm passes to the intestine and forms the adult worm by the addition of segments back of the head. This tapeworm in turn produces eggs and the cycle is repeated. Thus, certain tapeworms in the dog give rise to certain bladderworms in sheep, the tapeworm eggs in the feces of the dog being deposited on the pasture and picked up by sheep with the herbage that they eat. The dog in turn becomes infested with tapeworms when it eats the bladderworms in the meat, brain, liver, entrails, or other parts of the sheep.

Sheep may harbor adult tapeworms in the intestine and bladderworms in the body tissues.

THE MONIEZIAS.[8]

Location.—These tapeworms are found in the small intestines.

Appearance.—They are whitish to yellowish in color and may attain a length, in some specimens, of several yards (see fig. 13). The individual segments of a worm are broader than long, and each segment contains at some period of its development a complete set of reproductive organs. The end segments are full of eggs, and these segments break off from the rest of the worm and pass out in the manure, where they are often found by the farmer and regarded as complete worms. The presence of these segments in the feces serves to diagnose cases of infestation with the tapeworm.

Life history.—The life history of these tapeworms is not known. Sheep are herbivorous animals and would only by accident eat animals, such as insects, that might serve as intermediate hosts. It is possible that the intermediate hosts are small animals, such as insects, that are taken in by the sheep on grass, but we have no evidence on this subject.

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[8] *Moniezia expansa, M. trigonophora,* and *M. planissima.*

Distribution.—These tapeworms are more or less common throughout the United States. Two of the forms (*M. expansa* and *M. planissima*) are also widely distributed outside the United States.

Symptoms and lesions.—When these worms are present in sheep in large numbers they cause obstruction of the intestine and intestinal irritation, with the result that they interfere with digestion and the sheep become unthrifty, weak, and emaciated; such sheep are unable to stand adverse conditions, such as bad weather or poor food, and die where sheep not so infested may survive. The digestive derangement is manifested by diarrhea as a rule. It is known that tapeworms often cause very marked and even severe nervous symptoms in man, and while such symptoms are more difficult to detect in sheep, there is every reason to suppose that they may occur.

On post-mortem examination of affected sheep the tapeworms are found in the small intestine, often in large numbers. The sheep show no special indications of their presence other than poor condition, evidences of diarrhea, and inflammation or catarrh of the intestines.

Treatment.— Various treatments have been recommended. Among the remedies which have been used are the following:

Kamala.—This drug has been given in doses of 1 dram to lambs. It causes diarrhea and lambs so treated may remain poor for some time in spite of abundant food and good conditions otherwise.

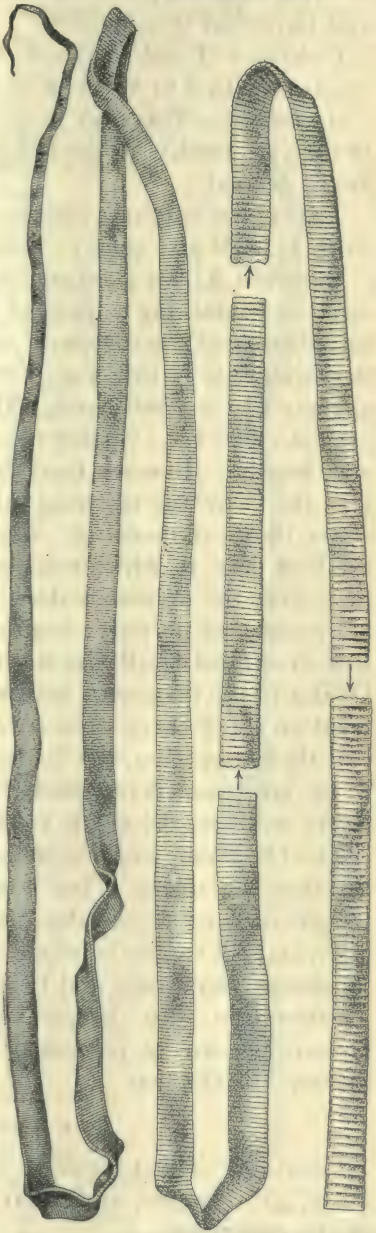

Fig. 13.—Tapeworm (*Moniezia trigonophora*). About natural size. (From Stiles, 1898.)

Kousso.—This is said to have given good results in doses of 2 drams to lambs.

Koussin.—This is reported as giving good results in 2-grain doses. It expelled the tapeworms, and the animals remained in good spirits and improved in condition.

Oleoresin of male fern.—This is given in doses of 1 dram and may be given with 2 to 4 ounces of castor oil.

Areca nut.—This may be given to lambs in doses of 1 to 3 drams. It must be freshly ground shortly before being used, preferably the day it is used.

The copper-sulphate treatment for stomach worms, given on pages 39 to 41, will also remove some tapeworms.

In South Africa good results have been reported from the use of a mixture containing 1 part of sodium arsenite (testing 80 per cent arsenious oxid) and 4 parts of copper sulphate. The total dose of the mixture is as follows: For animals 2 to 4 months old, 180 milligrams; 4 to 6 months old, 250 mg.; 6 to 10 months old, 375 mg.; 1 year old, 500 mg.; 2 years old or older, 625 mg. This may be given as a powder. Remove food and water the afternoon before dosing; dose the following morning; allow food that afternoon and food and water the next morning. The dose may be repeated the day after the first dose, in which case food is allowed the afternoon after the first dose, the animal is dosed the following morning and fed that afternoon, but no water is allowed from the afternoon preceding the first treatment until the morning following the second treatment. Owing to the poisonous nature of arsenic, it is best to test the treatment on a few sheep to be sure the dose is safe before dosing a flock, and the drugs should be kept out of reach of children and animals. If the treatment is repeated at intervals of a month or more through warm weather, the single treatment should be used.

The Oklahoma experiment station claims very good results from a solution containing 1 per cent copper sulphate and 1 per cent by weight of snuff or powdered tobacco. The tobacco is steeped overnight and the copper sulphate then added. The dose is 50 mils (about 1½ ounces) for lambs and twice this amount for full-grown sheep.

Prevention.—No dependable preventive measures against these tapeworms can be recommended, owing to the fact that the life history is unknown.

THE FRINGED TAPEWORM.[9]

Location.—This tapeworm is found in the small intestine, the gall ducts, gall bladder, and biliary canals of the liver, and in the duct of the pancreas.

Appearance.—These are whitish or yellowish tapeworms and may be a foot long (fig. 14), but are commonly shorter. They may be readily distinguished from other tapeworms by the fact that each

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[9] *Thysanosoma actinioides*

of the segments has a fringe on its posterior border. This fringe may be most easily seen when the segment is put in water, where the fringes can float out from the segment. Tapeworms found in the liver or pancreas will be this worm and not the Moniezias already described.

Life history.—As in the case of the Moniezias (and this is true of all the adult tapeworms of cattle, sheep, and horses), the life history is unknown. Presumably it has an intermediate stage, perhaps in an insect or other small animal.

Distribution.—The fringed tapeworm is a parasite of western sheep and is found in the East probably only when the sheep have been shipped from the West. The infected range is probably confined to North Dakota, South Dakota, Nebraska, Kansas, Oklahoma, and Texas, and the States west of these. The parasite apparently has found conditions most favorable among range sheep, and it seems to be losing ground with the breaking up of the big western sheep ranges and the substitution of small holdings of sheep.

Symptoms and lesions.—The obstruction of the bile ducts and pancreatic ducts causes inflammation of these ducts and derangement of the liver. As a result there is an alteration in the secretions as regards amount and character, which impairs digestion and causes a lack of thriftiness. This shows in lost flesh and poor quality of flesh and wool. Sheep weakened by fringed tapeworms may die from the parasitic infestation or from inability to withstand other adverse conditions. Infested sheep are commonly hidebound and suffer from diarrhea.

On post-mortem examination the tapeworms may be found in the intestine and in the liver and pancreas, and the ducts of these glands are usually found thickened when infested. In the spring of the year fringed tapeworms seem more likely to be found in the small intestine than at other seasons.

Treatment.—No successful treatment is known for this parasite. Such treatments as have been attempted have failed, and all that can be recommended at this time is careful nursing and good feeding.

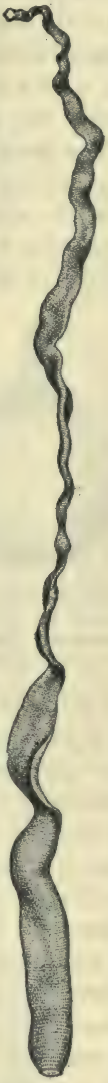

Fig. 14.—Fringed tapeworm (*Thysanosoma actinioides.*) About natural size. (From Stiles, 1898.)

Prevention.—As in the case of the Moniezias, the fact that we do not know the life history of this worm makes it impossible to give specific directions for preventing infestation.

BLADDERWORMS.

THE THIN-NECKED BLADDERWORM.[10]

Location.—The thin-necked bladderworm is found in the abdominal cavity attached to the mesenteries or omenta or in the liver.

Appearance.—The bladderworm looks like a sac full of a clear fluid, with a white object, which is the head and neck, projecting into it from one end. It is usually about 1 inch in diameter, but may attain a long diameter of several inches. The bladderworm proper is surrounded by a cyst, which is developed by the host animal as a protective measure against the parasite. When this cyst is broken the parasite usually rolls out and is seen to be a thin-walled structure. By careful manipulation the head and its rather long neck may be squeezed out at one end of the "bladder" (fig. 15).

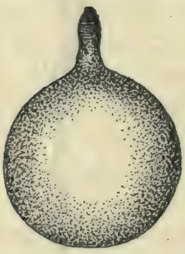
FIG. 15.—Thin-necked bladderworm (*Cysticercus tenuicollis*). Natural size. (From Stiles, 1898.)

Life history.—If one of these bladderworms is fed to a dog the cyst wall will digest, but the tapeworm head and neck will pass on to the small intestine of the dog and begin to grow segments back of the neck. In this way it will form a tapeworm, one of the largest of the dog tapeworms[11] (fig. 16). This tapeworm attains a length of a yard or more, becoming mature and beginning to liberate egg-bearing segments in the course of 10 or 12 weeks. When dogs infested with these tapeworms run over pastures used by sheep, they leave feces containing the tapeworm eggs on the pastures, and these eggs are spread by rain and washed on to the grass and into streams and puddles where the sheep drink. When the sheep get these eggs in food or water, the embryo escapes from its surrounding shell, makes its way to the liver of the sheep, and begins to develop. In time it slips out of the liver and becomes attached to the mesenteries or omenta. At first it is a bladder without a head, but later the head and neck develop, and it is then ready to infect any dog that eats it.

Distribution.—This parasite is quite generally distributed over the United States, but the indications are that the worm is becoming less common as a result of improvements in disposal of viscera and offal at slaughterhouses during the last 15 years. It is most likely to be present where sheep are associated with dogs, either when herded by them or where stray dogs are common, and where sheep are slaughtered on farms or at small country slaughterhouses at which little care is exercised in disposing of the viscera and of diseased portions of carcasses.

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[10] *Cysticercus tenuicollis.*

[11] Commonly called *Tœnia marginata,* and more properly *Tœnia hydatigena.*

Symptoms and lesions.—Light infestations with these bladderworms seem to do very little damage. Severe infestations, such as a sheep would get by eating grass that had an entire segment full of eggs on it, will make a sheep very sick and may kill it. Under these conditions sheep usually die at a rather early stage of the disease, and at a time when the embryos are wandering around in the liver, the immediate cause of death being hemorrhage from the liver, or peritonitis. Post-mortem examination under these conditions would seldom be sufficiently minute to reveal the exact cause of the trouble, and it would seldom be charged to the account of this parasite.

On post-mortem examination the bladderworms are usually readily observed in the mesenteries or omenta, or in earlier stages, in the liver. When the liver has just recently been invaded, the presence of the parasite is usually indicated by serpentine markings showing the course of the wanderings of the young worms.

Treatment.—There is no treatment for infestation with the bladderworm in sheep.

Dogs should be kept free from tapeworms of any sort, including the one responsible for this bladderworm in sheep. For removing these tapeworms, fast the dog from noon of one day until the following morning and then give one of the following treatments:

Oleoresin of male fern.—The dose for dogs is 15 minims to 1 dram (a quarter of a teaspoonful to a teaspoonful), according to size. This may be given in capsules and followed immediately by an ounce of castor oil.

Areca nut.—This may be given in the same amounts as the oleoresin of male fern, and will usually not need a purgative, as

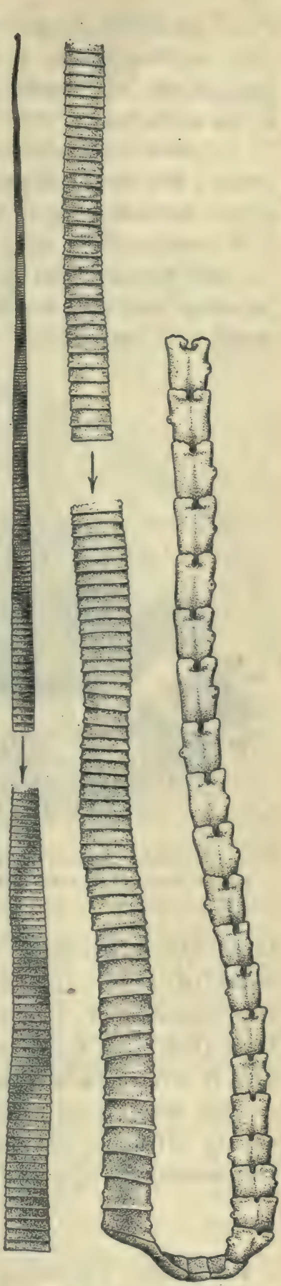

FIG. 16.—Tapeworm (*Tænia hydatigena*) of dog, developed from thin-necked bladderworm of sheep. About natural size. (From Stiles, 1898.)

areca is itself purgative. If feces are not passed in the course of four or five hours, it is advisable to give castor oil or some other purgative. As noted previously, areca nut must be freshly ground to be efficacious.

Arcoline hydrobromide.—For dogs of moderate size, one-fourth grain; for small dogs, one-eighth grain. No purgative should be given, as this drug is itself purgative.

Kamala.—This may be given in doses of half a dram to 2 drams (a half teaspoonful to 2 teaspoonfuls). The powder may be given in sirup and will not need to be followed by a purgative, as kamala itself is a purgative. As in the case of areca nut, if feces are not passed in four or five hours castor oil or some other purgative should be given.

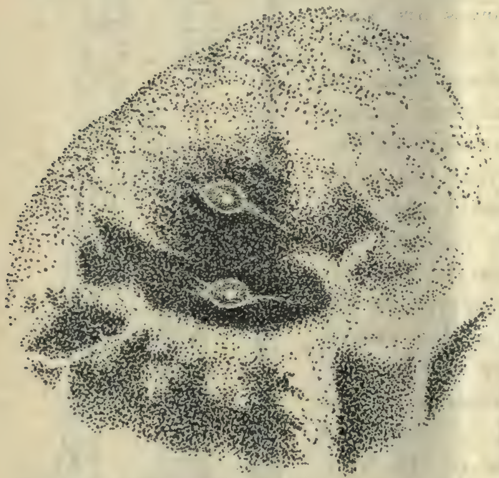
FIG. 17.—Sheep muscle showing measles (*Cysticercus ovis*). Natural size. (From Ransom, 1913.)

Any tapeworms that are passed and the feces with them should be burned. On the farm this is easily done by using hay or straw for fuel.

Prevention.—This consists in preventing dogs from eating uncooked meat, especially diseased and parasitized meat and viscera. Slaughterhouse refuse should be tanked and not left where dogs can have access to it. The use of the tank has apparently resulted in a diminution in the number of cases of this parasite in sheep and dogs, and the extension of this measure will probably eradicate it in time. Dogs should be kept free from tapeworms by suitable remedies, whenever necessary, and it would be advisable to give such treatment as a routine procedure about four times a year where there is any chance of dogs eating infective material. Stray dogs should be kept off farms and suppressed by appropriate measures.

SHEEP MEASLES.[12]

Location.—Parasites known as sheep measles occur in muscles, including the heart, and intermuscular connective tissue, and as degenerate cysts in the lungs, walls of the first and fourth stomachs, and the kidneys.

Appearance.—This parasite occurs in the meat (measly mutton) as oval cysts 3.5 to 9 mm. (one-seventh to one-third of an inch) long by 2 to 4 mm. (one-twelfth to one-sixth of an inch) wide. These cysts have a thin external membrane inclosing a clear fluid. On one side of the cyst is an opaque white object, which is the head and neck of a tapeworm (fig. 17). When degenerated the cysts appear as cheesy or hard nodules, the hardness being due to lime salts.

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[12] *Cysticercus ovis.*

Life history.—The life history of this parasite is similar to that of the thin-necked bladderworm, the adult being a certain species of tapeworm of the dog (*Tænia ovis*).

Distribution.—In the United States this parasite appears to be most common in the West, especially in Montana, Idaho, Washington, Oregon, California, Colorado, and Nevada. It has been found abroad in England, France, Germany, Algeria, German Southwest Africa, New Zealand, and South America.

Symptoms and lesions.—When sheep have but a few of these cysts no symptoms are likely to be observed, although it has been suggested that sheep measles may be responsible for the many stiff lambs found during spring and summer on the western sheep ranges. When many cysts are present sheep will become very sick, and if all the eggs from one segment are eaten by a sheep it is likely to die. On post-mortem examination the cysts are the principal thing observed, though in badly infested cases the meat may be watery and discolored.

Treatment and prevention.—These are the same as for the thin-necked bladderworm (pp. 25 and 26) and its adult tapeworm.

THE GID PARASITE.[13]

Location.—The gid parasite occurs in the brain or spinal cord. Degenerate worms that failed to reach the central nervous system may be found in muscles and other tissues.

Appearance.—This worm occurs as a large cyst or bladderworm, attaining the size of a hen's egg or larger, and is composed of a thin membrane containing a rather large amount of fluid. On the bladder membrane are a number of small white objects about the size of a grain of wheat, projecting, as a rule, into the bladder fluid (fig. 18). These are the tapeworm heads. A parasite of this sort is called a cœnurus.

Life history.—When such a bladderworm, or cœnurus, is eaten by a dog or coyote the bladder membrane digests, releasing the attached tapeworm heads. These heads then pass into the small intestine, where they form the adult tapeworm by the addition of segments back of the head (fig. 19). Ordinarily the worm is fully grown and 2 or 3 feet long in the course of a month or two, though occasionally a longer period is required. The full-grown tapeworm produces minute eggs, which pass out in the feces of the dog on to the pasture or range. Under favorable conditions these eggs are taken in by sheep with contaminated food or water. The shell digests from the egg and releases an embryo, which is armed with six hooks. By means of these hooks the embryo cuts its way through the tissues of the sheep and into the blood stream. In the blood the embryos are carried to various tissues, but only those that reach the brain or spinal cord are able to attain the full larval development, the others dying and degenerating by the time they reach the size of a pea. Those that reach the central nervous system at first move about on or in the brain or spinal cord, forming curving channels. At a suitable point the wandering ceases and the bladderworm grows and completes its development in about seven or eight months, the sheep dying in nine months or earlier.

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[13] *Multiceps multiceps.* Synonym, *Cœnurus cerebralis.*

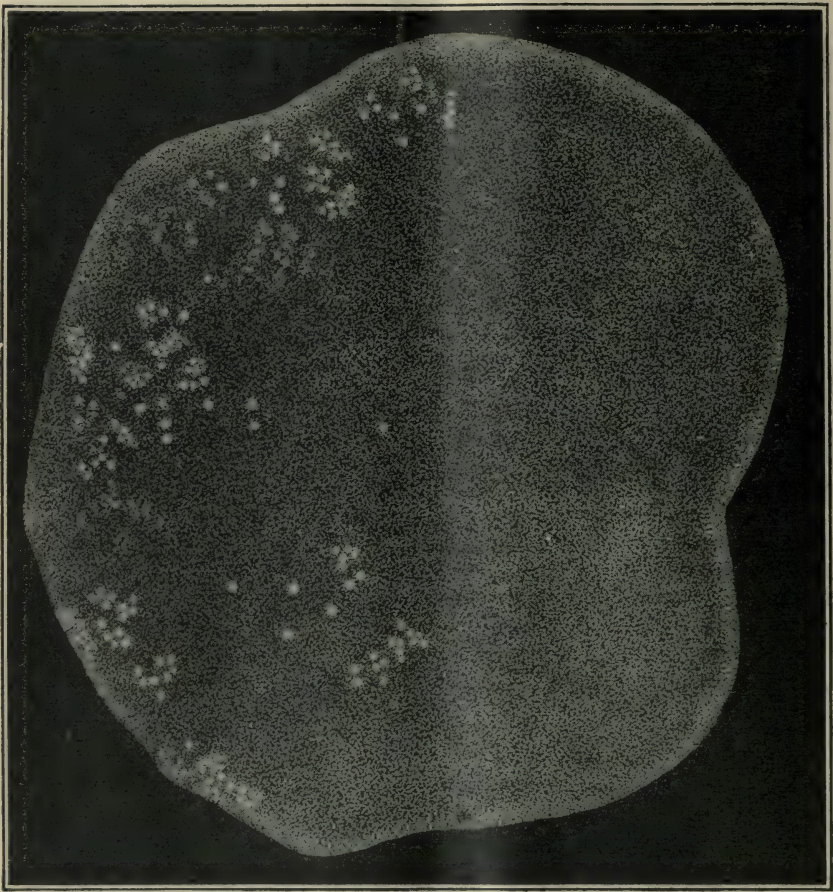

FIG. 18.—Gid parasite (*Multiceps multiceps*) from brain of sheep. Natural size. (From Hall, 1910.)

Distribution.—In the United States this parasite has been found chiefly in northern Montana, where it has been established for about 30 years, possibly longer. There have also been outbreaks of gid in Arizona and in New York. Cases have been observed also in various localities to which sheep have been shipped from infested regions. Occasionally cases are imported from Europe. Outside the United States the disease is known to occur in England, Scotland, Ireland, France, Germany, Austria, Hungary, Italy, Sardinia, Switzerland, Greece, Spain, Holland, Denmark, Iceland, Shetland, Morocco, Cape Colony, German Southwest Africa, South Australia, New Zealand, Argentina, Chile, and Canada.

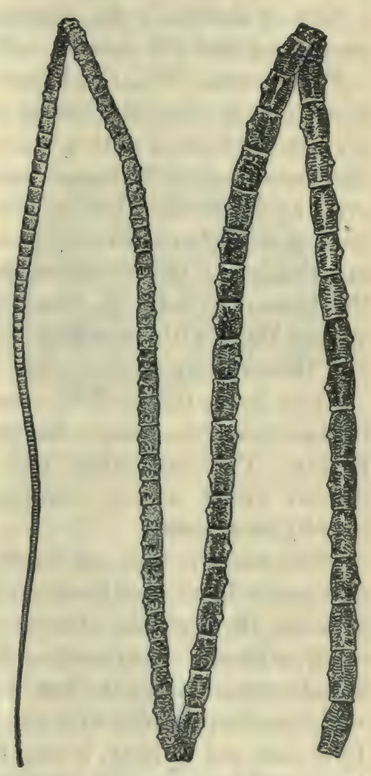

FIG. 19.—Tapeworm stage of *Multiceps multiceps* in dog. Actual size. (From Hall, 1910.)

Symptoms and lesions.—At the time that the young worm gets to the brain there are usually slight symptoms of fever and restlessness, which are easily overlooked. If the sheep dies at this time, as a result of severe infestation, an examination of the brain will show a number of curving channels on its surface. As a rule the symptoms of this stage abate and there is no further indication of the presence of the parasite until it has grown to the point where the heads form. This will take place about the seventh or eighth month after infection. The head of the worm can be evaginated from the bottom of its tubular neck, just as a glove finger may be turned inside out, and this brings its hooks and suckers into contact with the brain. From this irritation and from the pressure of the growing bladderworm there arise the very striking symptoms indicative of gid. Affected sheep very commonly walk in a circle, turning toward the side corresponding to the affected portion of the brain when the parasite is on the surface of the cerebrum. When the parasite is located at other points the symptoms are somewhat different. In these cases sheep may walk with the head held high and may step high, or with the head held low and with a stumbling gait, or may show other odd symptoms in the way of unusual locomotion. Such animals gradually lose interest in food and water and finally cease eating or drinking. In consequence they become very much emaciated. They may move about continuously or stop at times and gaze fixedly at nothing in particular. They are difficult or impossible to herd and tend to lag behind the flock or become lost. The head is often carried to one side and the animal may become blind or appear to be blind.

Unless surgical treatment or accident frees the sheep from its parasite, the animal will die, usually in the ninth month. When examined after death, the brain or spinal cord will be found to have on or in it a bladderworm, or more than one, and an equal amount of brain or cord tissue will be found to have disappeared or been crowded aside by the growth of the cyst. The skull adjacent to the parasite is often softened or even absorbed to the point where it has a hole or several holes through it. In the late stages sheep are so emaciated that the meat is unfit for food.

Treatment.—The treatment for gid is surgical. This is satisfactory only when the cyst is on the surface of the brain. Operation may be performed with a trocar and cannula or with a trephine. In the trocar and cannula operation the wool is sheared over the affected area, as determined by the symptoms and by palpation to find a soft spot or one where the sheep reacts violently to pressure. Under local anesthesia the trocar and cannula are driven through the skull and the trocar withdrawn from the cannula. If the cyst is struck, a watery fluid will issue from the cannula. This fluid is syringed out and the cannula withdrawn. Suitable cannulas are provided with a cleft to catch the bladder membrane and pull it out. If this fails, it is necessary to remove the membrane with forceps or by some other means. This operation, like operations generally, should be conducted under aseptic conditions. The median line of the skull should be avoided.

With the trephine outfit the wool is sheared over the proper area and under local anesthesia and aseptic conditions a V-shaped incision is made through the skin and the skin dissected back. A piece of skull is then cut out with a five-eighths-inch trephine and the hard membrane covering the brain is cut with bent scissors. The parasite will usually push out and may be grasped with forceps and removed. If it does not appear, it may be necessary to explore for it with the finger. After removing the parasite and controlling the hemorrhage, the skin flap may be sewed back along one side of the tip of the V, and the wound covered with a pledget soaked in some antiseptic. The animal should be kept quiet in a dark shed for several days after operation.

Some sheepmen cut the skull with a pocket knife or puncture the cyst with a knife. In such cases the sheep is apt to die of infection, even if the worm is removed. The operation for gid calls for care and should be performed by a competent veterinarian. If operation does not seem to be feasible, it is advisable to kill giddy sheep for mutton or send them to market before they become emaciated and unfit for food.

Prevention.—The most important preventive measure is to destroy the heads or at least the brains of giddy sheep. This may be done by burning. Where wood is scarce the skull may be split with an ax or cleaver and the brain put on a forkful of hay or straw and burned. Where this is not feasible the brain may be removed from the skull, crushed, and covered with formaldehyde, turpentine, or a coal-tar or tobacco dip. The essential thing is to destroy the parasite and prevent dogs, coyotes, or other animals from eating it.

Another measure of importance is to keep dogs, especially sheep dogs, free from tapeworms. To this end it is advisable that they be given tapeworm treatment four times a year. For the treatments that may be used see page 25. Measures against coyotes and other noxious wild animals are valuable in controlling gid as well as in keeping down the destruction of stock. Stray dogs should be eliminated on the same grounds.

THE HYDATID.[14]

Location.—The preferred sites of the hydatid parasite in sheep are the liver and lungs, but it may occur in practically any organ or tissue.

Appearance.—The parasite occurs in sheep usually as a multiple bladderworm, varying from the size of a nut to the size of a child's head, sometimes as a spherical object and sometimes irregular in shape (fig. 20). It has a very thick, laminated bladder wall, and in the simplest form of the parasite this bladder contains a clear fluid and minute objects resembling grains of sand lying unattached in the fluid. These grains are brood capsules, and each of them contains a number of very small tapeworm heads. Sometimes the bladderworm develops other bladderworms, attached or unattached, on the inside or outside.

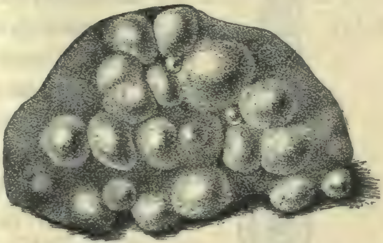

FIG. 20.—Hog liver infested with hydatid (*Echinococcus granulosus*). Greatly reduced. (From Stiles, 1898.)

Life history.—When the brood capsules from a hydatid are eaten by a dog, cat, or other suitable animal, each tapeworm head in the brood capsules develops into a tapeworm by the addition of segments back of the head. This tapeworm is a very small one, less than half a centimeter (about one-fifth of an inch) long (fig. 21). As the hydatid may form thousands of such heads in its brood capsules, dogs may become infested with large numbers of these worms on eating hydatids. The eggs produced by the adult tapeworms in the dog pass out in the feces. When taken in by a sheep or other animal the egg hatches and releases an embryo which makes its way to some suitable tissue and develops to the hydatid. This hydatid may develop in man if an egg of the tapeworm is swallowed, and a large percentage of hydatid infestations in man result in death. It is therefore a very dangerous parasite to human beings.

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[14] *Echinococcus granulosus.*

Distribution.—This parasite has been found at a number of places in the United States proper and in Alaska, as well as in other parts of the world. Certain regions are found to send a large number of infected swine to the slaughterhouses, though its occurrence in sheep is comparatively rare in the United States. Where it is locally prevalent, its abundance may be attributed to infected dogs which have probably become infected through carelessness in the disposal of diseased carcasses and viscera of slaughtered animals. Careless persons may feed diseased portions of carcasses to dogs or leave them where dogs will get at them and eat them.

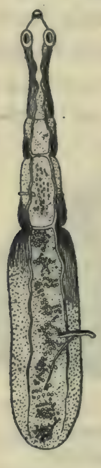

FIG. 21.—Hydatid tapeworm (*Echinococcus granulosus*). Highly magnified. (From Stiles, 1898, after Leuckart.)

Symptoms and lesions.—The symptoms in sheep affected with hydatid depend on the location of the parasite and its size, and so are very variable. Where the parasite is small or has room to develop without crowding important organs, few symptoms may be noticed. On the other hand, the parasite may develop in such structures as the brain or heart and cause very marked symptoms and sudden death from pressure or rupture. As a rule, infestations will not be detected and correctly diagnosed during the life of a sheep and they will be found only on post-mortem. In such cases the large, thick-walled bladders are readily found.

Treatment.—The only treatment for this condition is surgical, and this is not apt to be feasible in sheep, even if the disease should be diagnosed ante-mortem.

Prevention.—The most important measure in the way of prevention of this disease is the proper disposal of carcasses and portions of carcasses of animals dying on the farm or killed there or elsewhere. The " condemned " tank at the modern slaughterhouse has been one of the greatest factors in destroying parasites of this sort, and the lack of an equally good arrangement at the small country slaughterhouse and on the farm is one of the important conditions which permit such parasites to persist. Where diseased viscera, such as livers infested with hydatid, are thrown out where dogs can get at them, parasites of this kind are liable to be prevalent. The next measure of importance in controlling this disease is to keep dogs free from tapeworm by administration of tapeworm treatments four times a year. For these treatments, see page 25. Owing to the danger of persons acquiring hydatid diseases and the serious nature of this disease in man, dogs known to harbor this tapeworm should be killed and burned or buried deep in quicklime.

FLUKES.

Flukes are usually flat, leaflike animals, provided with suckers, but not segmented like the tapeworms. They occur in the adult stage in various locations, the stomach, intestines, liver, lungs, and blood vessels, and may occur in immature stages in such tissues as the muscles. The adult flukes produce eggs of microscopic size which pass out and hatch in water. The embryos released from the eggs infect snails in which they transform into a succession of larval stages. The parasites finally escape from the snails and may penetrate the skin of the final host or may be swallowed, sometimes after encysting, in food or water.

Sheep in certain localities in the United States, as well as in other parts of the world, suffer considerably from fluke infestation. The common liver fluke and the large liver fluke occur in American sheep.

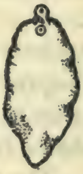

FIG. 22.—Common liver fluke (*Fasciola hepatica*). Natural size. (From Stiles, 1898.)

THE COMMON LIVER FLUKE.[15]

Location.—These flukes are found usually in the biliary canals and the ducts of the liver, though they may occur as wandering parasites in the lungs and elsewhere.

Appearance.—The common liver fluke is a flattened, leaflike, brown animal, usually about an inch long (fig. 22). There is a sucker at the anterior, or front, end, on a cone-shaped extension, and just behind this is a ventral sucker. Through the skin or cuticula covering the animal one can see the branching intestine and the uterus filled with eggs.

Life history.—The eggs produced by the adult flukes pass out in the feces and on getting to water release a ciliated embryo. This embryo attacks certain species of snails and on entering the snail undergoes certain changes, which in time give rise to a form called a cercaria. This is like a small fluke provided with a tail by means of which it swims about. Finally it loses the tail and encysts. The encysted cercariæ may float about on or in water or may be attached to grass blades or other vegetation. When these are swallowed by sheep, or other suitable host animals, the larval flukes escape in the digestive tract and bore their way through the intestinal walls to the body cavity. Here they wander over the surface of the viscera and the walls of the body cavity and as a rule finally perforate the capsule of the liver and reach the extremities of the biliary canals. A few go astray and perforate the diaphragm, getting to the lungs. In the liver the young flukes grow and make their way down the canals, the larger ones being found in the bile ducts, and begin again the life cycle with the formation and passage of eggs.

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[15] *Fasciola hepatica.*

Distribution.—This parasite occurs over a large part of the world, where low, wet pastures and the presence of suitable snails make it possible for it to exist. In the United States it occurs on the Atlantic and Pacific coasts in places, and along the Gulf of Mexico. In these regions it occurs in wet pastures, especially along rivers and tributary streams. The States in which the fluke is most prevalent are Washington, Oregon, California, Texas, Arkansas, Louisiana, Alabama, and Florida. It is also prevalent in Porto Rico and Guam.

Symptoms and lesions.—Sheep are likely to put on fat and seemingly improve in condition in the early stages of liver-fluke disease, usually in the summer and fall, apparently as a result of a stimulation of the functions of the liver. Later, however, they lose in condition. The skin and mucous membranes are paler and the animal is less lively. The animal feeds less and ruminates less. Edema appears as the composition of the blood is altered, and may be seen as swellings along the pendant portions of the body, for example, in the region under the jaw. During the winter the sheep becomes leaner, breathes rapidly and feebly, and is dejected. A diarrhea is usually present at a late stage of the disease.

Animals may die at any stage of the disease, but if they survive the attack the flukes leave the sheep in the spring and a part of the damage is repaired. Total recovery is hardly possible, as the liver is burdened with scar tissue in the areas where the flukes have been. The disease may be diagnosed from its symptoms, if one is familiar with it, but a safer diagnosis is based on the finding of the worm eggs in the sheep manure.

For the purposes of the farmer and sheepman the surest diagnosis is made by killing a sick sheep and making a careful post-mortem examination. If the ducts of the liver are carefully slit and examined, the flukes will be found as dark, leaflike objects which, if watched a short time, will show movement. The liver may be washed in a plentiful supply of clear water as it is cut up, and the water examined for the flukes that may wash out. The liver of infected sheep is softened and roughened, and may show channels under its capsule. In old cases puckered scar areas are present.

The softening of the liver is what gives the name of "liver rot" to the disease. The biliary canals and gall ducts are much thickened and enlarged and often are marked by ridges on the surface of the liver.

Treatment.—The two remedies which have been found satisfactory are male fern and kamala. According to some writers, however, kamala is much less efficacious than male fern.

Oleoresin of male fern is administered as follows: Give by mouth 3 to 5 grams of the male fern (from ¾ of a teaspoonful to 1¼ teaspoonfuls), according to the size of the sheep, in 10 mils (2½ teaspoonfuls) of a nonpurgative oil, in the morning, two hours before feeding. Administer the treatment on five consecutive mornings. The male fern should contain 24 to 25 per cent of filicine and 3.5 per cent of filicic acid.

Powdered kamala is administered as follows: To yearlings and older sheep give 15 grams divided into two doses of 7.5 grams (2 drams) each, and give at 12 to 24 hour intervals. The entire 15 grams may be given in one dose to a strong animal or divided into five doses for weak ones. After treatment sheep are dull for 3 to 5 days, they lie down a great deal, eat little or may stop eating for a day or two, and have a diarrhea. The flukes are said to die in 3 to 8 days.

It is advisable to have these drugs administered by a competent veterinarian.

Prevention.—The manure from infected sheep should not be put on pasture, especially on wet ground. Sheep should be kept off wet pasture in places where fluke is prevalent and swampy areas should be drained, filled, or fenced off. Dressings of lime and salt on pastures in June, July, and August have been recommended for killing the embryos and larvæ of the fluke and for killing and repelling snails. It is said that sheep never become infected with flukes on salt marshes. Infected sheep should be isolated and either treated for fluke or butchered before they have lost condition and become unfit for food. Where fluke is present in a flock, it is advisable to treat the flock at the beginning of winter after the danger of fresh infestation is past. Frogs, toads, and carp are useful in the control of snails. Safe drinking supplies must be provided for sheep as the infection may be water-borne.

The Oregon agricultural experiment station has recently recommended the addition of copper sulphate (bluestone) to standing water or streams in pastures to destroy the snails which are the necessary intermediate hosts of liver flukes. After ascertaining the volume of standing or running water to be treated, add one ounce of copper sulphate to 7,800 gallons of water or about one part of copper sulphate to one million parts of water. This will kill snails in 48 hours, but will not not kill the eggs. Repeat this treatment in two or three months, after the eggs hatch. The solution is not injurious to the higher plants and animals or for bathing, drinking or irrigation, but it may injure fish.

THE LARGE LIVER FLUKE.[16]

Location.—The large liver fluke occurs in the liver, commonly lying in cysts which contain one to several flukes and a quantity of dark-colored fluid filled with débris. While these cysts may originate in a biliary canal, they extend into the tissue, and the fluke is habitually found as a parasite in the liver substance in cysts and not as a parasite of the canals and ducts. Wandering flukes may be found in the lungs or elsewhere.

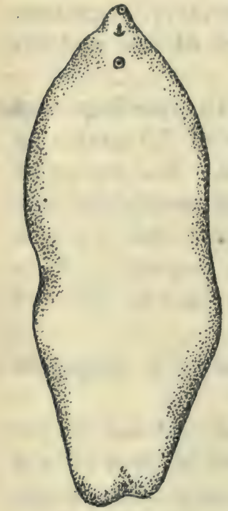

FIG. 23.—Large liver fluke (*Fascioloides magna*). Natural size. (From Stiles, 1898.)

Appearance.—This is a large, thick species, which may attain a length of 10 cm. (4 inches) (fig. 23). The anterior, or front, sucker is not carried on a distinct cone, as in the case of the common liver fluke, but in its general appearance otherwise it resembles an overgrown specimen of the common liver fluke.

Life history.—The life history of the large liver fluke has not yet been ascertained, but there is every reason to suppose that it is much the same as that of the common liver fluke, with snails of some sort, perhaps the same as those which carry the common liver fluke, as intermediary hosts.

Distribution.—North America appears to be the home of this fluke, although it has been transplanted elsewhere. In the United States it is most prevalent near the Gulf of Mexico, especially in Arkansas and along the coasts and river valleys of Texas. It also occurs along the west coast in both the United States and Canada and seems to have obtained a foothold at some inland points, as in part of Colorado. Cases are also reported from Wisconsin and New York.

Symptoms and lesions.—This parasite is much more common in cattle than in sheep. It seems to do rather little damage in cattle apart from rendering the livers unfit for use as food. In sheep, however, it may do considerable damage. Infected sheep lose condition, but the appetite persists up to the time of death. Edema is present in the form of watery swellings of the dependent portions of the body. Abortions have been reported as prevalent in a flock of infested sheep, though it is unsafe to associate this with the fluke without further evidence.

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[16] *Fascioloides magna.* Synonym, *Fasciola magna.*

On post-mortem examination the livers show the characteristic cysts or else dark-bluish scars where the flukes have been and where healing has taken place. The flukes apparently die in the liver instead of passing out in the spring, as the common liver fluke does. The cysts take on the character of abscesses and may be present in the lungs and spleen as well as in the liver. Affected livers and other organs contain more or less coal-black pigment characteristic of the presence of this parasite. The worms may set up peritonitis, and the omentum may show black markings.

Treatment.—No treatment is known for this disease, though the use of oleoresin of male fern or kamala is indicated as for the common liver fluke.

Prevention.—The same measures that are used in the case of the common liver fluke (see p. 35) are indicated here. As already noted, while we do not know the life history of this fluke, the probabilities are that the measures indicated will apply.

ROUNDWORMS.

The parasitic roundworms or nematodes are elongated, cylindrical, unsegmented worms. Some of them may be properly characterized as threadlike or hairlike. The body wall is usually rather transparent, and when the worms are examined with a microscope the internal organs are readily seen, usually in the form of a number of tubes. The sexes are generally separate and the males are usually smaller than the females. In general the females produce large numbers of eggs, though sometimes the eggs hatch in the body of the female and some roundworms produce embryos without the previous formation of an egg with its yolk material and shell.

Most of the roundworms of sheep reach the animal in which they develop to maturity through the direct swallowing of the eggs or young worms without passing through part of their development in some intermediate host, as the tapeworms do. In some cases the young worms that have hatched in the fields penetrate the skin of the host animal, entering the body in this way instead of by the mouth. Other worms have an intermediate host and undergo a certain development in this host before getting to the final host. The intermediate host harboring the larval worms may be eaten by the final host, thus infecting it through the digestive tract, or such intermediate hosts as mosquitoes may infect the final host by inoculating it with the larval worms which then penetrate the skin.

Even in the case of direct infection, when eggs or young worms are swallowed by the host animal, nematodes which develop to maturity in the intestine may not go directly there and develop immediately. They may pass through the walls of the digestive tract and get to the blood stream, leave the blood stream for the air passages of the lungs, crawl up the windpipe, and then pass down the esophagus or gullet, and thus reach the intestine again, where they continue their development to maturity.

THE STOMACH WORM.[17]

Location.—This worm is a parasite of the fourth stomach. It may be found elsewhere in the digestive tract, but such occurrences are of little significance.

Appearance.—Stomach worms (fig. 24) are from one-half to 1¼ inches long and about as thick as an ordinary pin. The females are the larger and have a spiral striping. In the rear half of the body of the female there is a projecting portion, which may be seen on close examination. The smaller male may be distinguished by the fact that the posterior or tail end of the body is flattened and expanded.

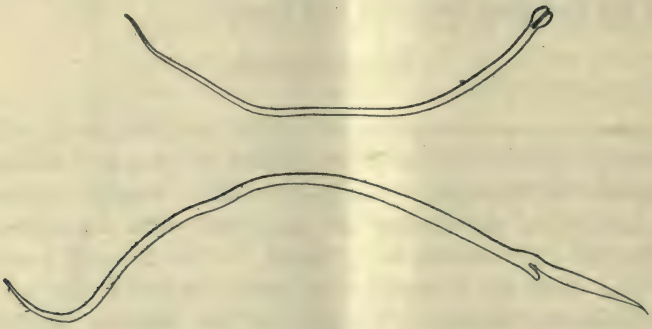

FIG. 24.—Stomach worms (*Hœmonchus contortus*). Upper figure, male; lower, female. Magnified five times.

Life history.—The eggs produced by the female worms pass out in the manure and hatch in a few hours under the most favorable conditions of warmth and moisture. Under less favorable conditions hatching may require a number of days or even weeks. The embryo which leaves the egg undergoes further development until it becomes an ensheathed, infective larva. In this condition it is inclosed in a double skin and is very resistant. Whereas drying and low temperatures may kill the egg or embryo previous to this stage, the ensheathed larva can withstand severe cold and long periods of dryness. When the grass is wet with rain or dew, these larvæ crawl up the blades. Here they are swallowed by sheep as they graze. In the stomach the worms become mature in the course of two to three weeks, but do not begin to produce eggs in large numbers until about a month after they are taken in by the sheep.

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[17] *Hœmonchus contortus.* For additional information see Department Circular 47 on "Stomach Worms in Sheep."

Distribution.—The stomach worm occurs over almost the entire world, wherever there are sheep, cattle, or other suitable host animals. In the United States it is most plentiful in the South, where it is favored by abundance of warmth and moisture, but it is quite a common and serious pest in the Middle West and in low, wet areas throughout the entire country. It is present in smaller numbers and does less damage in the high, dry, and cool areas of the Rocky Mountain States.

Symptoms and lesions.—The first things noticed about infested sheep are dullness and lack of thrift. Diarrhea may be present. Later, the more characteristic features of stomach-worm disease become evident in the form of anemia and edema. The anemia is manifested in the paleness of the skin and of the linings of the mouth and eyelids, and is due to the impoverishment of the blood from the bloodsucking habit of the worms. The edema is manifested in a swelling of the pendant portions of the body, especially of the portion under the jaw, causing what is called "bottle jaw." Sheep may become emaciated and finally die.

If the fourth stomach of a sheep infested with stomach worms is opened (the fourth stomach is the one to which the upper end of the small intestine attaches), the worms can usually be seen as wriggling red objects. When the contents of the stomach are poured out many of the worms will usually remain attached to the lining of the stomach. A little careful washing will reveal the worms if they are covered by the stomach contents. Close investigation of the lining of the fourth stomach will also reveal the pin-point punctures caused by the bites of the worms. There are usually a number of these for every worm, as the worm has the habit of attaching at one point for a time and then moving away and attaching at another point, leaving the old point of attachment bleeding for some time. The carcass of a sheep seriously infested with stomach worms is liable to be emaciated and the meat pale.

Treatment.—A satisfactory treatment for this disease is the use of a 1 per cent solution of copper sulphate in water. A dose which has been found satisfactory is 100 mils (about 3 ounces) for yearlings and older sheep and half as much for lambs 3 months old or older. To make this solution, dissolve one-fourth pound of copper sulphate in 1 pint of boiling water, then add cold water to make a total of 3 gallons of the solution. Porcelain or enamel-ware receptacles should be used for the solution, as bluestone (copper sulphate) will corrode metal. This amount will dose 100 adult sheep, allowing 10 per cent waste. Use only clear blue crystals of copper sulphate,

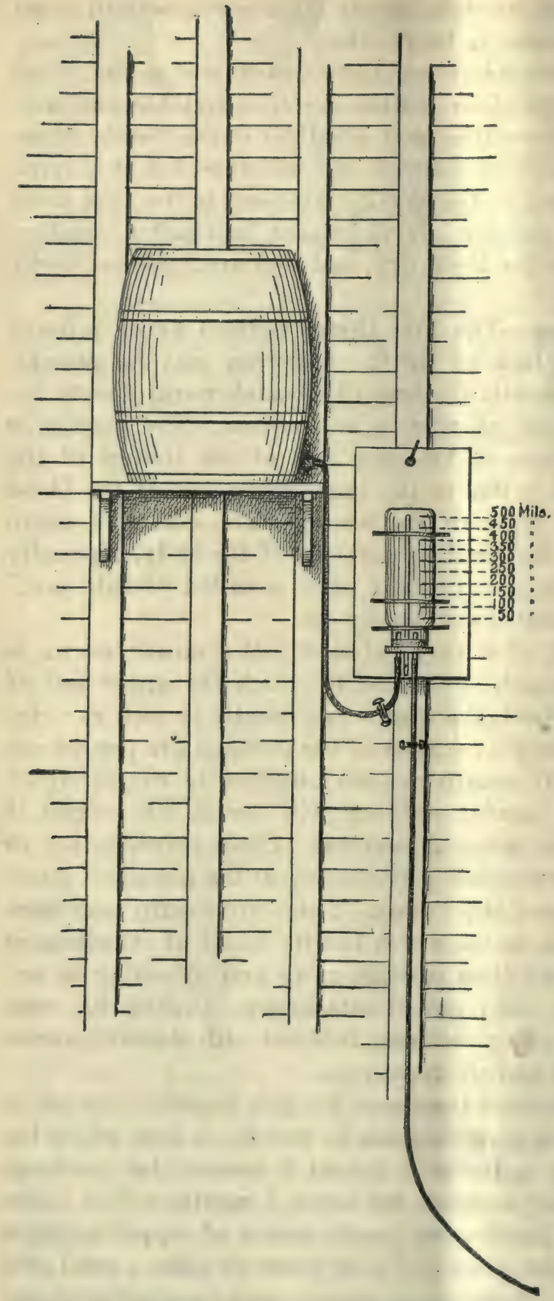

FIG. 25.—Dosing device for administering copper-sulphate solution.

discarding the pieces that have turned white. Crushing the crystals will hasten solution. In dosing, one may use a rubber tube with a funnel on one end and a piece of metal tube at the other. The metal tube is placed in the sheep's mouth and the solution slowly poured through the funnel. If large numbers of sheep are to be treated, the apparatus figured (fig. 25), or something similar to it, may be used. The copper-sulphate solution is fed from a high reservoir, by siphoning or by a tube or spigot near the bottom, through a rubber tube into an open graduated glass tube, which may be made from a large olive jar, and allowed to escape in measured doses through the other rubber tube to the metal tube in the sheep's mouth. Instead of an open graduated glass tube, a large bottle or jar may be used if a third tube is put in the jar, through the cork, one end being open to the outside and the other opening near the bottom of the inverted jar, to equalize air pressure. This is shown in figure 25. The flow into and out of the glass tube is controlled by pinchcocks, one person attending to this and one holding the metal tube in the sheep's mouth. The sheep should remain on all four legs, with the head held horizontally while it is being drenched, which decreases the danger of getting the drench into the lungs and killing the sheep. The solution should be allowed to flow slowly and the metal tube be moved about slightly in the mouth at the same time in order to keep the sheep swallowing. It is essential that the copper-sulphate solution be made up accurately, be given in suitable doses, and be administered with care, and it is advisable to have a competent veterinarian give this treatment or the ones noted below in order to insure a maximum degree of safety.

The sodium-arsenite and copper-sulphate mixture and the copper-sulphate and tobacco solution, recommended for tapeworm, have also been recommended as effective against stomach worm (p. 22).

Carbon tetrachlorid in doses of 12 to 48 cubic centimeters (3.2 to 12.8 fluid drams) in 2 fluid ounces of castor oil has been found to remove all stomach worms from sheep in experimental tests. See remarks under "The nodular worm," page 42.

Prevention.—Preventive measures are based on the life history. We know that the disease is spread by eggs produced by the female worm, which escape in the manure on to the pastures. Infested sheep must be regarded as a danger to young and uninfested sheep. The manure from the infested sheep is likewise dangerous. Consequently, young animals and uninfested sheep should be separated from older or infested animals and not exposed to contact with the manure from these animals. Furthermore, pastures which have been used by infested animals are dangerous to young animals and uninfested ones. When animals that have stomach worms, either in a light or heavy infestation, are put on clean pasture, the eggs of the stomach worm will hatch on the ground and the infective stage of the worm will be present on the grass in considerable numbers in from 10 to 20 days, or even earlier in warm weather. The longer the sheep are on that pasture under ordinary weather conditions the more dangerous it will become from the increasing number of worms. To prevent getting dangerous infestations, it is advisable that sheep be moved every two weeks to clean pasture. Inasmuch as pastures probably remain infected for about a year after sheep, goats, or cattle are moved from them, the program of moving sheep to new pasture, where permanent pastures are used, is a rather difficult one and calls for more land than is usually available. Consequently a modification of this program is necessary.

The first essential is to protect the lambs. Young animals are more susceptible to parasitic infestation than older ones. They also suffer more from parasites when they are infected. Growth must be made during youth; it can not be made up in mature years. Parasites interfere seriously with growth and lead to the production of runts. Consequently the safest pasture should be furnished to the lambs, the older sheep taking the more dangerous pasture, where it is necessary for sheep to go back to old pasture within a year. It may be mentioned in passing that hillside pastures are likely to be safer than bottom land, as they benefit by the cleansing action of heavy rains and the following run-off, as well as holding less moisture, lack of moisture being very unfavorable to the worms. Rich bottom pastures, on the other hand, are the ones which are least likely to have an infection washed off and are likely to have the eggs and larvæ from the hillsides above washed on to them. The more or less abundant moisture, moreover, is highly favorable to these worms. It is precisely these bottom pastures which are likely to be used for young animals, as they present the best growth of grass and are most attractive.

In a plan of rotating pastures to keep down stomach worms, the sheep may be moved over cornfields, hayfields, and stubble of various sorts. During freezing weather, the eggs and nonresistant early stages of the young worms on pasture diminish as they are killed by freezing, so that the pastures at this time, while still infected, do not become increasingly dangerous. Plowing is a means by which infestation may be controlled, the young worms being turned under and buried; apparently they do not get back to the surface in numbers sufficient to cause serious trouble. Such plowed land may be sown to forage crops and the sheep turned in on these crops with safety. When different kinds of stock are rotated on pastures, sheep may safely follow horses or swine, but not cattle or goats, as these latter also may be infected with stomach worms and a number of other worms common to sheep, goats, and cattle.

At the Bureau of Animal Industry sheep farm at Vienna, Va., it has been found highly beneficial to dose sheep with copper-sulphate solution once every three or four weeks throughout the year, sheep thus treated showing no losses from stomach worms and making decided gains in wool and mutton over sheep kept under the same conditions but not treated. This appears to be the best control measure for use in the case of sheep kept under the usual farm conditions.

THE NODULAR WORM.[18]

Location.—The adults of the nodular worm live in the large intestine of the sheep. The larval worms live in nodules in the wall of the large and small intestine, and occasionally make their way to the mesenteric lymph glands, the omentum, or the liver. The nodules are most numerous in the wall of the large intestine.

Appearance.—The female worms attain a length of 15 mm. (about five-eighths inch), the males being a little shorter (fig. 26). Both sexes have a characteristic solid white color. The head is bent over and forms a hook with the body.

Life history.—The details of the life history of this worm are not completely known. The eggs from the female in the large intestine of the sheep are passed in the manure. The subsequent development of the worm up to the time it is again found in the sheep has not been determined. When the young worms are first found in the sheep they are encysted in the wall of the intestine. These cysts commonly reach a considerable size and contain a necrotic material, usually yellowish or greenish in color, cheesy in consistence or often hard and almost stonelike (fig. 27). After a time the larvæ leave these nodules and become adults in the lumen of the large intestine. Usually larvæ can be found only in the smaller and more recent nodules. Those larvæ which get to the mesenteric lymph glands, the omentum, and the liver probably die in these places and never get back to the intestine to complete their development.

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[18] *Proteracrum columbianum.* Synonym, *Œsophagostomum columbianum.*

Distribution.—This parasite was originally present in this country only in the Southern and Eastern States, but it has been spreading westward, probably with infested sheep introduced into western localities for breeding purposes, and there is reason to fear that it will become generally distributed over the country. It has become rather common in the Middle West, and is a serious pest in the Northeastern States. It is still uncommon in the Rocky Mountain States, and as yet has not been reported from a number of these States.

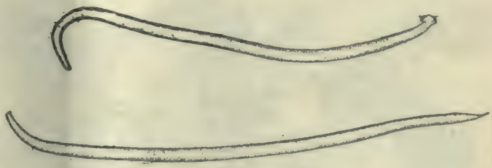

FIG. 26.—Nodular worm (*Proteracrum columbianum*). Upper figure, male; lower, female. Magnified five times.

Symptoms and lesions.—According to one investigator (Curtice) the symptoms of this disease may be only those of general debility—a pale mucous lining of the eyelids and mouth, emaciation, dry wool, etc. In severe cases diarrhea and emaciation may be excessive. In some places sheep raising has been abandoned on account of the damage done by this worm. It is evident that the injury due to numerous intestinal nodules, which prevent large areas of the intestine from functioning properly in the work of secretion and absorption, which act as persistent irritants to the sensitive nervous system of the digestive tract, and which serve to supply poisonous material from worms, bacteria, and dead tissue to the adjacent absorbing tissues of the intestines, can not fail to have a bad effect on the host animal. The resultant loss can not be accurately stated, but it occurs in terms of meat, wool, decreased growth, and poorer quality of animals and from the fact that nodular intestines, or so-called "knotty guts," are unfit for sausage casings.

The post-mortem lesions are easily seen, the principal ones being the nodules, which may be larger than a good-sized pea, on the walls of the large and small intestines, or in the mesenteric lymph glands, the omentum, or the liver. The nodules may be small, elevated objects, or may be larger and contain cheesy or limy matter, white, greenish, or yellowish in color. These nodules are sometimes mistaken for lesions of tuberculosis, a rare disease in American sheep.

Treatment.—As yet we have no satisfactory treatment for this disease. The larval worms in the nodules are beyond the reach of any remedies as yet known to us. Even the adult worms in the large intestine are difficult to remove. There is some difficulty in getting a suitable drug past the four stomachs of a ruminant and into the large amount of food matter in the large intestine in sufficient strength to remove these worms. Experiments in the Bureau of Animal Industry have indicated that carbon tetrachlorid in doses of 12 to 48 cubic centimeters (3.2 to 12.8 fluid drams), given in 2 ounces of castor oil, will sometimes remove all the nodular worms present in an animal, but may remove only a small percentage. This treatment will also remove all the stomach worms and hookworms, as a rule, and will remove many of the thread-necked strongyles and related worms, and many whipworms. The carbon tetrachlorid treatment is new and requires further study to determine the safety of the treatment. It is advisable to secure prompt purgation with carbon tetrachlorid. The treatment should be administered by a competent veterinarian.

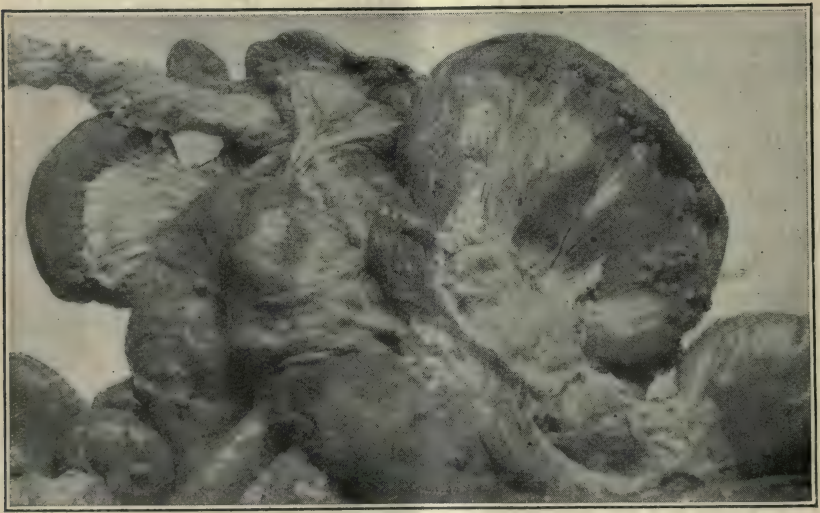

FIG. 27.—Sheep intestines showing lesions of nodular worm disease.

Prevention.—Pasture rotation, as given in the case of the stomach worm, is a valuable control measure. Dalrymple found that he could practically prevent the nodular worm infection of lambs by raising them in bare lots, where there would be no temptation to graze and where surroundings would be unfavorable for the development of the parasite. The ewes were let into these lots whenever necessary to nurse the lambs. The lambs were given other feed from raised racks and watered from raised troughs. The racks and troughs were protected from fecal contamination and the floor of the yard cleaned frequently to keep it free from litter and manure, thereby preventing the development of the eggs in the manure in the yards. As in most parasitic diseases, the young animals suffer more than older ones and measures must be directed especially to the protection of the lambs. If persisted in, these measures and pasture rotation should keep the infestation down to a point where it does little damage.

THE SHEEP HOOKWORM.[19]

Location.—Hookworms of sheep are found in the small intestine.

Appearance.—The female hookworm attains a length of 2.6 cm. (about 1 inch), the male attaining a maximum length of 1.7 cm. (fig. 28). The worms are about one-half to three-fourths as thick as an ordinary pin. At the head end is a mouth capsule armed with teeth. The tail end of the male is expanded and flattened.

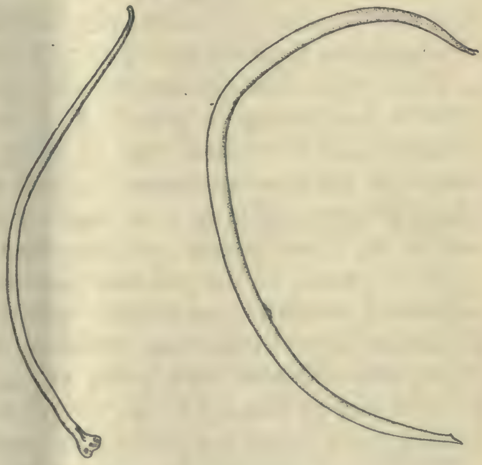

FIG. 28.—Sheep hookworm (*Bunostomum trigonocephalum*). Female at right; male at left. Magnified. (From Ransom, 1911.)

Life history.—The life history of the sheep hookworm has received little attention, but, judging from the life history of related forms, it is probably about as follows: The eggs produced by the female worm in the intestine of the sheep pass out in the manure and hatch on the pasture. Under favorable conditions of temperature and moisture the young worms develop to a resistant form capable of infecting sheep. Possibly most of the infection takes place by way of the skin, the larval worms boring through the skin of the lower part of the legs and making their way to the near-by blood vessels. In the blood the worms would be carried to the lungs, where they would escape from the blood and get into the air passages. Here they would make their way up the windpipe and then down the gullet into the stomach and intestine. When they reach the intestine they develop to adult worms and the two sexes mate. In addition to the possible entrance of larvæ through the skin, many of the infective larvæ on the pasture are undoubtedly swallowed by the sheep in food or water, but even in this case it is possible that the larvæ make their way to the blood stream from the digestive tract and return by way of the lungs again before developing to maturity.

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[19] *Bunostomum trigonocephalum.* Synonym, *Monodontus trigonocephalus.*

Distribution.—This parasite is common in sheep in the Southern States and has been found as far north as New York. Additional studies in various localities would doubtless show a wider distribution. It is apparently fairly common in Europe.

Symptoms and lesions.—The symptoms resulting from infestation with the sheep hookworm have not received much attention, but its habits are similar to those of the hookworm in man and in the dog, and these are known to cause very serious damage, so that there can be little question as to the damage that hookworm may do in sheep. The worms are bloodsuckers, with the habit of attaching for some time at one place and then moving to another, leaving the first puncture still bleeding. This bleeding persists for some time, as the result of a secretion from the mouth parts of the worm which has the power to dissolve the blood corpuscles and prevent clotting.

With hookworms in general it is not uncommon to see 10 or 12 hemorrhages associated with a single worm. This loss of blood results in its impoverishment, as well as in a net loss in amount of blood present. This in turn causes a seepage of the thinned blood out of the blood vessels and into the tissues, causing watery swellings, or edema, of the pendant portions of the body, as well as an associated condition, or dropsy, within the body. With the impoverishment of the blood the nutrition of the animal is impaired—a a very serious matter with young animals. We may safely infer that there is serious damage to the sheep's nervous system, preventing its smooth functioning and making for poor animals and poor offspring.

The things that may be looked for in connection with hookworm disease are paleness of the mucous lining of the eyelids and mouth, pale skin, dry wool, watery swellings under the jaw and along the abdomen, and a general condition of unthriftiness. The condition is very similar to that found in stomach-worm disease, as the two worms affect the host animal in substantially the same way. As it is usually complicated with stomach-worm disease, hookworm infestation is not apt to be recognized as a distinct disease. The only way to make a satisfactory diagnosis between the two conditions is by a post-mortem examination of the fourth stomach and the small intestine in order to ascertain which of the worms is present. In some cases both species of worms will be found and the results may be attributed to the mixed infestation. The lesions caused by the hookworm are red spots, or small hemorrhages, in the small intestine, while similar spots in the fourth stomach are caused by stomach worms.

Treatment.—Oil of chenopodium (American wormseed oil) in doses of about 1 dram (1 teaspoonful) in about 5 ounces of milk has been found experimentally to remove about two-thirds of the hookworms present, and petroleum benzine (a high-grade gasoline) has been found to remove about three-fourths of the worms when given in doses of a half ounce in milk. In view of the greater safety in the use of chenopodium, this remedy seems preferable. A second treatment may be given after a lapse of two weeks. The copper-sulphate and tobacco solution recommended for tapeworms has also been recommended for hookworms.

Carbon tetrachlorid in doses of 4 to 30 cubic centimeters (3.75 to 8 fluid drams), in capsules or in 2 ounces of castor oil, has been found to remove all the hookworms from infested sheep. See remarks under "The nodular worm," page 44.

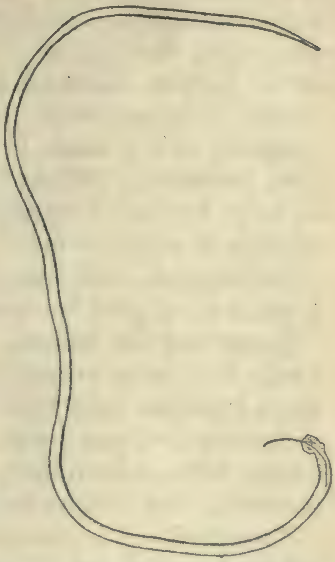

FIG. 29.—Thread-necked strongyle (*Nematodirus spathiger*). Male, greatly magnified. (From Ransom, 1911.)

Prevention.—Pasture-rotation methods, as outlined under the subject of stomach worms, will be found of great value in controlling sheep hookworms. Proper disposal of the manure, which carries the eggs of the worm, is also important. In view of the fact that this worm possibly enters the sheep through the skin of the legs as well as through the mouth while the animal is grazing, boggy land and loose, wet, sandy soil may be looked on with suspicion as apt to convey the infection by bringing the larvæ in contact with the skin in mud or wet sand.

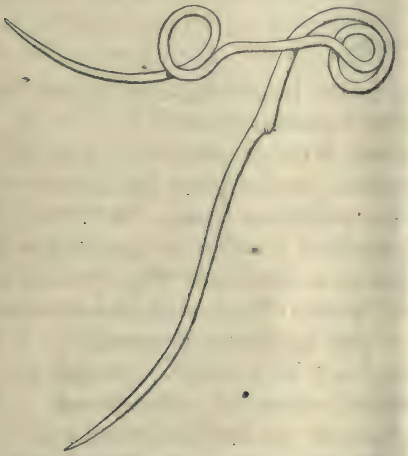

FIG. 30.—Thread-necked strongyle (*Nematodirus spathiger*). Female, greatly magnified. (From Ransom, 1911.)

THE THREAD-NECKED STRONGYLES.[20]

Location.—The thread-necked strongyles are found in the small intestine.

Appearance.—These are reddish worms, the anterior portion more slender than the posterior. The head and the neck end are transversely striated. In *N. spathiger* the male worm attains a length of 1.5 cm. (3/5 inch). The female attains a length of 2.3 cm. (about 1 inch).

Life history.—The eggs produced by the female worm pass out in the feces and an embryo develops in them. This worm molts twice in the shell, the skin that separates at the second molt, however, remaining on the larva. The larva hatches under the influence of alternate moistening and drying or of temperatures of 24° to 32° C. (75° to 90° F.). Like the stomach worm, the ensheathed larva then ascends blades of grass under favorable conditions of temperature and moisture, and is taken in by sheep as they feed. These larvæ are very resistant to cold and drying, and have also been found to live in water for over 11 months. In the intestine of the sheep the larvæ develop to adult worms.

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[20] *Nematodirus filicollis, N. spathiger,* etc.

Distribution.—At least one species of these worms (*N. spathiger*) appears to be quite common in sheep in the United States.

Symptoms and lesions.—When present in small numbers it is unlikely that these worms do much damage, but sheep infested with large numbers have been found to be unthrifty. So far the only symptoms that may be attributed to them are those commonly associated with gastrointestinal parasitism in general—those of malnutrition. No definite lesions have yet been described for this worm.

Treatment.—The treatment for infestation with this worm has not yet been worked out. Carbon tetrachlorid in doses of 12 to 48 cubic centimeters (3.2 to 12.8 fluid drams) in 2 ounces of castor oil has been found very effective in a few cases in removing these worms and is the only drug which has been found of value. See remarks under "The nodular worm," page 42.

Prevention.—The same measures that are of value against stomach worms will probably be of value against the thread-necked worms.

THE WHIPWORM.[21]

Location.—The whipworm occurs in the large intestine, usually in the cecum, but rarely elsewhere in the digestive tract.

Appearance.—The body of this worm is thick posteriorly and very slender anteriorly, the anterior portion of the body being two or three times as long as the posterior portion, from which fact it receives the name of whipworm. The thick portion is comparable to a whip handle and the thin portion to a whiplash (fig. 31). The male is 5 to 8 cm. (2 inches to over 3 inches) long, with the anterior portion of the body three times as long as the posterior portion. The male spicule is 5 to 6 mm. long, and has a long sheath, covered with spines and terminating in a bulbous enlargement. The female is 5 to 7 cm. long, with the anterior portion of the body twice as long as the posterior portion. The eggs of the whipworms are characteristically lemon-shaped.

Life history.—So far as is known this worm has a simple life history. The eggs produced by the adult worm pass out in the feces and an embryo develops in each egg under suitable conditions of temperature and moisture. When these eggs are swallowed by sheep, the embryos develop to adult worms.

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[21] *Trichuris ovis.*

Distribution.—These worms are very common in sheep in the United States and many other countries.

Symptoms and lesions. — It has been found that whipworms in man set up a low-grade inflammation, with distinct symptoms of discomfort and distress. In animals, inflamed areas are quite commonly found where whipworms attach. The head end of the worm is usually found sewed into the mucosa, and, as the mouth is unarmed, it appears that the penetration of the mucosa is perhaps due to the digestive action of a substance secreted by the worm. There is likelihood of the lining of the intestine being infected by bacteria through the entrance of the worm, or of the burrow becoming infected subsequently. Though there are no well-defined clinical symptoms for whipworm infestation in sheep, it can not be doubted that the worms exert an injurious effect, more pronounced when the worms are numerous. On post-mortem examination the thick posterior ends of the worms will be found in the lumen of the intestine, the anterior ends being in the mucosa.

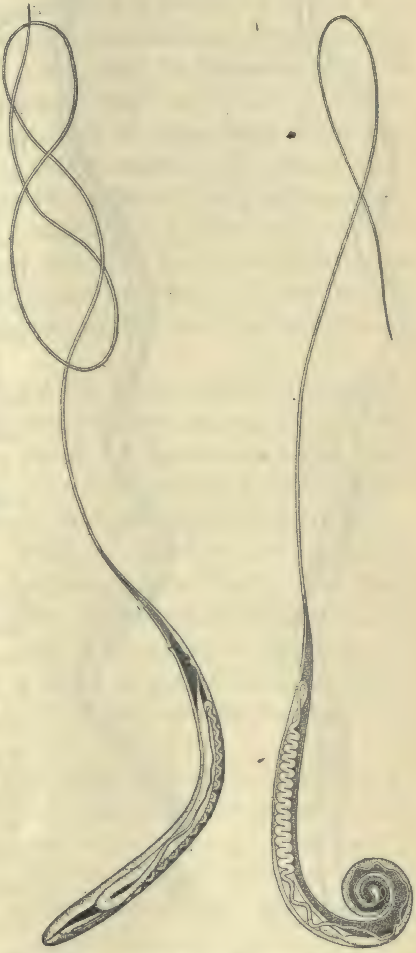

FIG. 31.—Whipworms (*Trichuris ovis*). Female at left; male at right. Magnified. (From Curtice, 1890.)

Treatment.—Carbon tetrachlorid in doses of 12 to 48 cubic centimeters (3.2 to 12.8 fluid drams) in 2 ounces of castor oil has been found to remove 30 to 90 per cent of the whipworms from sheep in experimental tests. See remarks under "The nodular worm," page 42.

Prevention.—Prevention of whipworm in sheep is a matter of sanitation and pasture rotation. The same measures that are useful in controlling stomach worm will be found of value in controlling whipworm.

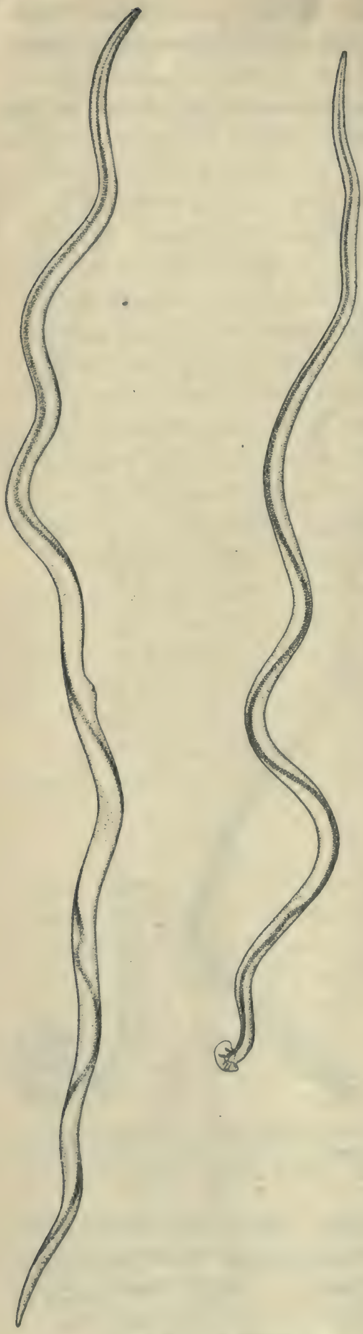

FIG. 32.—Thread lungworms (*Dictyocaulus filaria*). Male at right; female at left. Highly magnified. (From Curtice, 1890.)

THE THREAD LUNGWORM.[22]

Location.—The thread lungworm is found in the air passages, bronchi and bronchioles of the lungs.

Appearance. — These are rather long worms, easily observed. They are white and the intestine shows as a dark hair line throughout the length of the worm (fig. 32). The male is 3 to 8 cm. (from more than 1 inch to more than 3 inches) long. The female is 5 to 10 cm. (2 to 4 inches) long, with a straight, conical tail. The eggs contain an embryo when they leave the body of the mother worm.

Life history.—The eggs deposited by the female hatch in the lung of the host animal, probably in the course of 24 hours, and are expelled in coughing, or swallowed and passed in the feces. The newly hatched larva has a rounded head and a rather blunt tail. It molts twice in the course of the next few days, the time varying with temperature and moisture, and, under ordinary circumstances, is infective within 10 days. This larva then climbs up grass blades, when they are wet and the weather is warm, as does the larva of the stomach worm and thread-necked worm, and here it is taken in by grazing sheep and makes its way to the lungs. In the course of a month the sheep begin to show symptoms of lungworm, and in about five weeks embryos appear in the manure.

Distribution. — These worms are widely distributed over the world and are comparatively common in the United States, especially in the South and where there is plenty of moisture and warmth.

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[22] *Dictyocaulus filaria.* Synonym, *Strongylus filaria.*

Symptoms and lesions.—The worms and their eggs and larvæ set up an irritation of the lung tissue at the point where they are located, causing inflammation and a catarrhal condition, the latter manifested in the production of a frothy mucus, sometimes containing traces of blood. Bacterial infection of the weakened lung tissue may follow, and the lungs may show pus and consolidated areas. Usually the latter conditions are not present. The symptom first noted is a husky cough, and if the invasion is extensive this may be followed by difficulty in breathing. If left alone some animals are likely to die of weakness or suffocation. The disease may be diagnosed from the clinical symptoms by an experienced veterinarian or stockman who is familiar with it; the diagnosis may be confirmed by a microscopic examination of the feces or of the saliva from the back of the tongue, though occasionally one may not find larvæ, especially in recent infections, in spite of the presence of worms in the lungs. On post-mortem the lungs show inflamed patches, and the worms can be found in the air passages.

Treatment.—Most of the treatments by intratracheal injections that have been used for lungworm disease of cattle are not very satisfactory and are rather dangerous to sheep. A treatment which has been used on a large number of animals with reports of satisfactory results consists in injecting chloroform in 3-mil doses (about three-fourths of a teaspoonful) into the nostrils of the sheep by means of a medicine dropper, the head of the sheep being tilted back. The nostrils of the sheep are then held with the fingers until the animal is somewhat groggy. This treatment may be repeated at intervals of three to five days, if necessary, for a total of not more than three doses. It is recommended that a dose of Epsom or Glauber's salt be given two hours after the treatment.

Nursing treatment appears to be the safest and most satisfactory treatment in most cases. Sheep should be taken off wet pasture and placed on high, dry pasture or put up and fed dry feed. A safe supply of drinking water and plenty of good feed are of value in tiding the sheep over the critical stages of the disease and allowing the worms to die out.

Prevention.—The same general rules that apply in the case of the stomach worm apply here. Sanitation and pasture rotation, isolation of infested animals, and special precautions in regard to the pasturing and watering of lambs and young animals are all measures of value.

THE HAIR LUNGWORM.[23]

Location.—These worms occur in the small bronchioles and in the lung tissue.

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[23] *Synthetocaulus rufescens.* Synonym, *Strongylus rufescens.*

Appearance.—Hair lungworms (figs. 33 and 34) are much smaller than the thread lungworms. The body has a characteristic brownish-red color, due to the color of the intestine. The male is 1.8 to 2.8 cm. (about two-thirds inch to a little more than 1 inch) long and terminates at the tail in a corneus arc, followed by the small bursa (fig. 33). The female is 2.5 to 3.5 cm. (1 to 1.4 inches) long, with a moderately pointed tail.

Life history.—The life history of the hair lungworm has not yet been worked out, but it is probably similar to that of the thread lungworm.

Distribution.—The parasite is widely distributed and has been found to be fairly common in the United States. It is perhaps less common than the previous species or is possibly found less often because it is smaller.

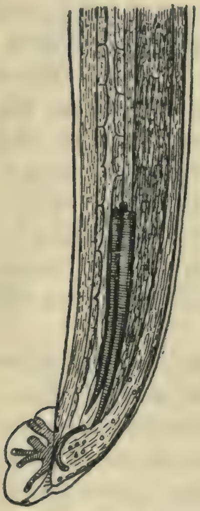

FIG. 33.—Hair lungworm (*Synthetocaulus rufescens*). Tail of male, viewed from side. Magnified. (From Railliet, 1893.)

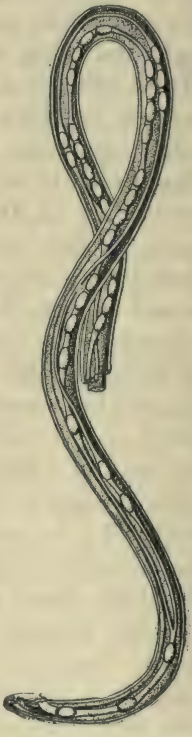

FIG. 34.—Hair lungworm (*Synthetocaulus rufescens*). Tail of female, viewed from side. Magnified. (From Curtice, 1890.)

Symptoms and lesions.—These worms occasion various forms of verminous pneumonia. The adult worms cause a lobular pneumonia; the eggs and larvæ cause a diffuse pneumonia, or when aggregated in the pneumonic areas may cause a pneumonia with areas resembling tubercles. These areas show as grayish-yellow tumors, which may attain a diameter ranging from a few millimeters to 2 centimeters (four-fifths of an inch). Careful post-mortem examination of these pneumonic areas will disclose the reddish worms, and the eggs and larvæ may be found by microscopic examination of such tissue. The weakened tissues afford lodging for disease-producing bacteria, sometimes leading to pus formation, in which case the evil effects are considerably increased. Sheep will survive an infection with worms which prevents only a small amount of lung tissue from functioning, but heavy infections reduce the amount of living tissue available for breathing to an extent that often proves fatal, and bacterial complications add to this and to the toxic material which is absorbed to the injury of the animal.

Treatment.—We have little evidence in regard to a satisfactory treatment for this worm, but the nursing treatment given for the preceding species would probably be the best procedure.

Prevention.—The preventive measures outlined for the thread lungworm apply here.

OTHER INTERNAL PARASITES.

Various other kinds of roundworms besides those that have been mentioned infest sheep, and some of them at times prove very injurious. The methods of prevention recommended for stomach worms, hookworms, and others in this bulletin, will help to protect sheep also from these other roundworms. There are also certain species of flukes, tapeworms, protozoa, and arthropods, other than those discussed here, which are omitted because they are relatively less important, so far as we are aware at present.

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U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1331

BACK-YARD POULTRY KEEPING

IN every household, no matter how economical the housewife, there is a certain amount of table scraps and kitchen waste which has feeding value but which, if not fed, finds its way into the garbage pail.

Poultry is the only class of domestic animals which is suitable for converting this waste material, right where it is produced in the city, into wholesome and nutritious food in the form of eggs and poultry meat.

Each hen in her pullet year should produce 10 dozen eggs. The average size of the back-yard flock should be at least 10 hens. Thus, each flock would produce in a year 100 dozen of eggs which, at the conservative value of 40 cents a dozen, would be worth $40.

By keeping a back-yard poultry flock the family would not only help in reducing the cost of living but would have eggs of a quality and freshness which are often difficult to obtain.

This bulletin is a revision of and supersedes Farmers' Bulletin 889

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BACK-YARD POULTRY KEEPING.

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ADVANTAGES OF HOME POULTRY.

The keeping of a small flock of laying hens on a town or village lot or in a city back yard is an important branch of poultry keeping. Though the value of the product from each flock is small of itself the aggregate is large. The eggs and fowls from such a flock may be produced at a relatively low cost, because of the possibility of utilizing table scraps and kitchen waste which otherwise would be thrown away. A small flock of hens, even as few as six or eight, should produce eggs enough, where used economically, for a family of four or five persons throughout the year, except during the molting period of the fall and early winter. By the preservation of surplus eggs

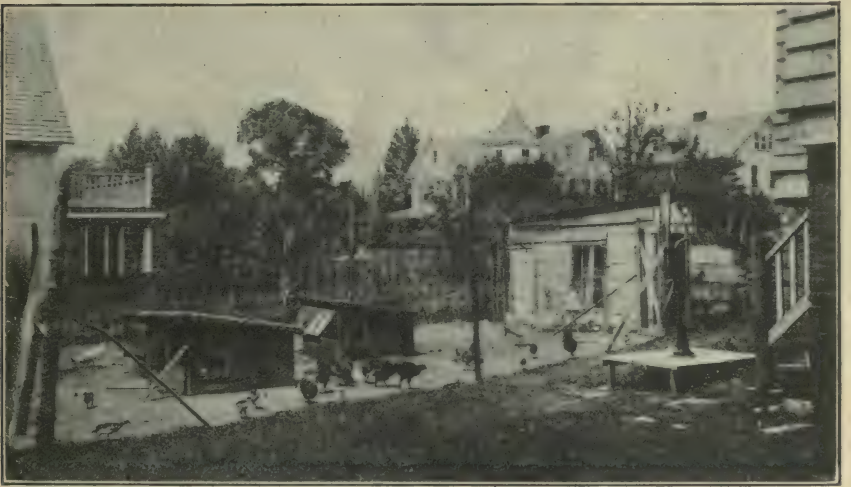

FIG. 1.—Poultry house and run in a back yard.

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[1] Mr. Slocum resigned Aug. 11, 1921. This bulletin was revised by Alfred R. Lee, poultryman, Animal Husbandry Division.

laid during the spring and early summer this period of scarcity can be provided for. The keeping of pullets instead of hens also will insure the production of eggs at that time. Not only will the eggs from the home flock materially reduce the cost of living, but the superior freshness and quality of the eggs are in themselves well worth the effort expended. Eggs are a highly nutritious food and are so widely used as to be almost indispensable, and an occasional chicken dinner is relished by every one.

Where conditions render it feasible and cheap, small flocks of poultry should be kept to a greater extent than at present by families in villages and towns, and especially in the suburbs of large cities. The need for this extension of poultry raising is particularly great in those sections where the consumption of poultry products exceeds the production, with the result that prices are high.

OVERCOMING OBJECTIONS TO KEEPING POULTRY IN THE CITY.

Objection is frequently raised to the keeping of poultry in towns and cities because of the odor which may result and also because of the noise which is made by roosters crowing, particularly in the early morning. In some cases city regulations have been formulated to prevent or to control poultry keeping. Where there are city regulations it is necessary to find out their provisions and to conform to them. There is no necessity for the poultry flock to become a nuisance to neighbors. If the dropping boards are cleaned daily and the houses and yards are kept in a reasonably clean condition there will be no annoying odors.

The male bird need not be a nuisance. Unless it is intended to hatch chickens from the flock it is unnecessary to keep a male bird. The fact that there is no male in the flock will have absolutely no effect on the number of eggs laid by the hens. If it is desired to mate the hens and to hatch chicks the male bird should be disposed of just as soon as the hatching season is over. This is desirable not only to eliminate noise, but also to save the feed that the male would eat and to produce infertile eggs, which keep much better than fertile eggs and consequently are superior for preserving or for market.

The flock must be kept confined; otherwise the hens will stray into neighbors' yards and gardens, where they may cause damage and are almost sure to cause ill feeling.

KIND OF FOWLS TO KEEP.

Householders usually desire not only eggs for the table and for cooking, but also an occasional chicken to eat. For this reason one of the general-purpose breeds, such as the Plymouth Rock, Wyandotte, Rhode Island Red, Orpington, or Jersey Black Giant, is preferable to the smaller egg breeds, such as the Leghorn. Not only do the mature fowls of those breeds, because of their larger size, make better table fowls than the Leghorns, but the young chickens for the same reason make better friers and roasters, whereas chickens of the egg breeds are only suitable for the smaller broilers. The general-purpose breeds are also "broody" breeds, the hens making good sitters and mothers, which is a decided advantage when chickens are to be hatched and raised. The hens of the egg breeds seldom "go broody" and are in any event rather unreliable sitters and mothers. If, however, the production of eggs outweighs the desire for an occasional table fowl, the lighter egg breeds undoubtedly will be found better, because they lay as many eggs and do so on less feed, with the result that they produce the eggs more cheaply. It is by all means advisable to keep some pure breed or variety. Where this is done, sales at a profitable figure can often be made of breeding stock or of eggs for hatching.

SIZE OF FLOCK.

The size of the flock which can be most efficiently kept will depend first of all upon the space available and, secondly, upon the amount of table scraps or other waste which is available for feed. It is a mistake to overstock the available space. Better results will be obtained from a few hens in a small yard than from a larger number. The back-yard poultry flock rarely will consist of over 20 or 25 hens and in many cases of not more than 8 or 10, or occasionally of only 3 or 4. For a flock of 20 to 25 hens a space of not less than 25 by 30 feet should be available for a yard. Where less space is available, the size of the flock should be reduced, allowing on the average 20 to 30 square feet per bird. A few hens are sometimes kept successfully with a smaller yard allowance than this, but if the space is available a yard of the size indicated should be used.

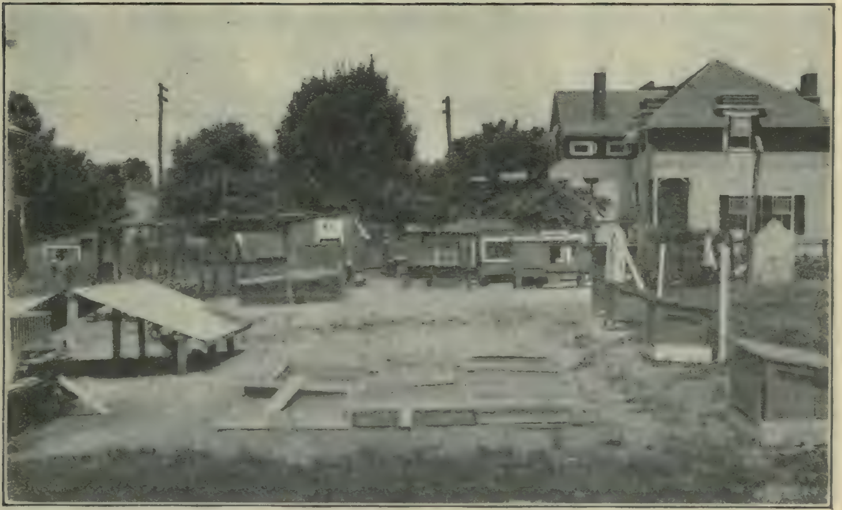

FIG. 2.—A back-yard poultry plant. In the background are the poultry houses set up off the ground on account of rats. At the left is a shade made of wooden strips and roofing paper. At the right are the coops for the hens and chicks. In the foreground oats for green feed are being sprouted under wire screens.

PROCURING STOCK.

The best way for the city poultry keeper to procure stock is either to purchase it in the fall or to buy day-old chicks or hatching eggs. An effort should be made to obtain pullets rather than older hens, and the pullets selected should be well matured, so that they will begin to lay before the cold weather sets in. Evidences of the maturity of pullets are the development and red color of the comb and a size and growth which are good for the breed or variety. Day-old chicks are sold extensively throughout the country and can be obtained in any number desired at moderate prices. It is not so desirable for the suburban poultry keeper to purchase eggs for hatching, although this is done successfully by some persons. The raising of small chicks, especially under congested conditions or where very little ground is available, is much more difficult than rearing them where one has free range or large yards. Growing chicks should have plenty of green feed, which is best supplied by a good grass range. When 200 or more day-old chicks are bought the only extra equipment required is a stove brooder, as all the chicks can be purchased at one time. If a smaller number of chicks are to be raised it is usually preferable to raise them with hens.

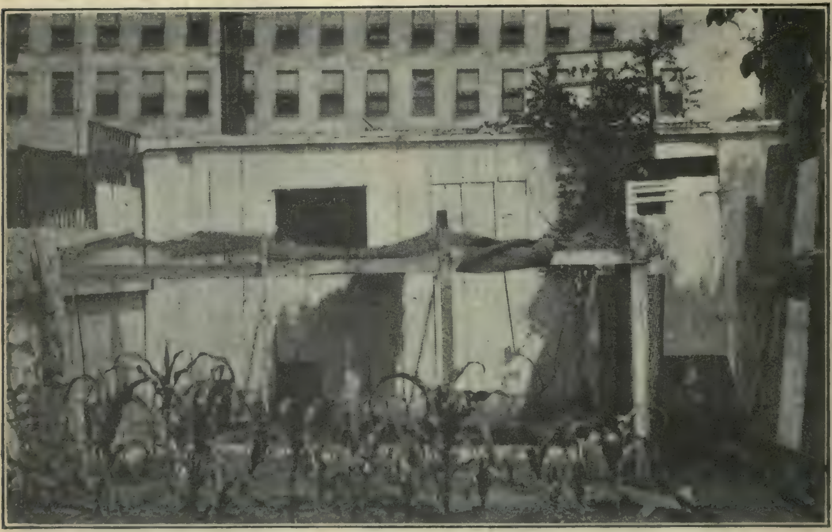

FIG. 3.—A shed in the heart of the city, utilized for a poultry house. While a larger opening in the front would admit more light and make a more suitable henhouse, the fowls kept here have done very well. The wire netting used for the yard was purchased very cheaply at an auction. The grass and sacks shown on the top of the run are used to furnish shade.

When pullets are to be purchased, it is well, if possible, to go to some farmer or poultryman who may be known to the prospective purchaser. Often the local poultry associations are glad to help the prospective poultry keeper to get stock by putting him in communication with some of its members having stock for sale. Sometimes the local board of trade or chamber of commerce is glad to bring together the prospective purchaser and the poultry raiser.

HOUSING.

The flock should be comfortably but not expensively housed. A house which provides a floor space of 3 or 4 square feet per bird is ample for the purpose, and fowls are often successfully kept with an allowance no greater than 2½ to 3 square feet. Houses must be dry and free from draft, but must allow ventilation. Often there is an unused shed or small building on the place which can easily be converted into a chicken house. (See Fig. 3.) The front of the poultry house should face toward the south, if possible, so that the sun will shine into it. Where there is a board fence it is sometimes possible to take advantage of this by building the poultry house in the corner of the fence, and making the fence itself, with the cracks covered by strips or battened, serve as the back and one side of the house. (See Fig. 4.) Perfectly satisfactory houses can be made cheaply from piano boxes or other packing cases. Two piano boxes with backs removed can be nailed together and a door cut in one end. These boxes should be covered with roofing paper in order to keep the house dry and to make it wind-proof. A portion of the door should be left open or covered with a piece of muslin, so as to allow ventilation. (See Figs. 5 and 6.) Similar houses can be constructed of packing cases at a relatively small cost. A small amount of 2 by 4 or 2 by 3 lumber can be purchased for framing. The box boards can be applied for siding or sheathing and then covered with roofing paper.

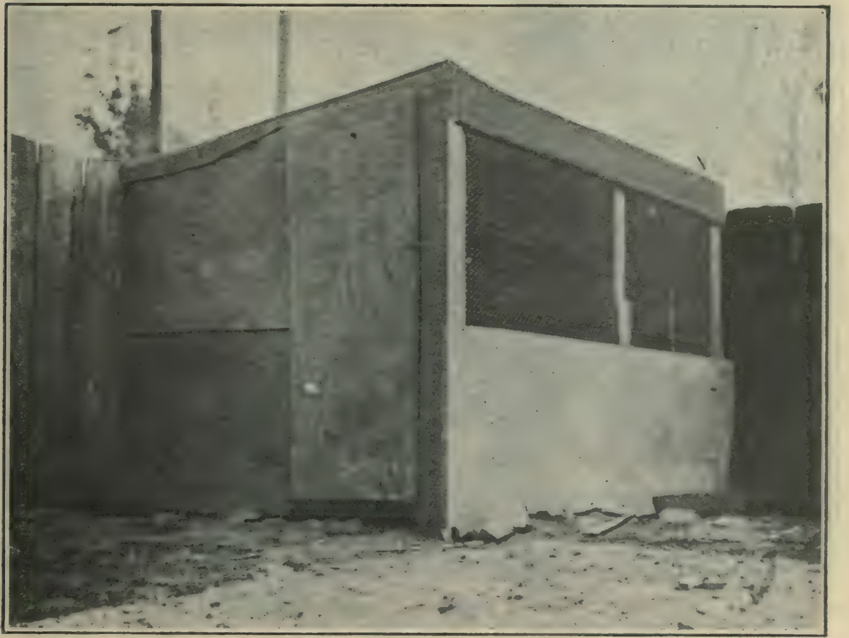

FIG. 4.—Poultry house built in the corner of a board fence, utilizing the fence for the back and one side of the house.

A cheap house 8 by 8 feet square can be made of 2 by 4's and wide boards. Plans for such a house are given in Figure 7. The 2 by 4's are used for sills, plates, corner posts, and 3 rafters. No studding is required except that necessary to frame the door and window space. The boards are run up and down and add sufficient stiffness to the house. They are used also for the roof and covered with roofing paper. The back and sides of the house also can be covered with roofing paper, or the cracks can be covered with wooden battens or strips 1½ to 3 inches wide. In the front of the house should be left a window or opening that can be closed, when desired, by a muslin screen or curtain, which serves as a protection against bad weather but allows ventilation. In the side a door should be provided which will allow entrance. A shed or single-slope roof is most practical because easiest to build. A height of 6 feet in front and 4 feet in the rear is ample. If desired, the house may be built higher, so that it is more convenient to work in; the increase in cost will be slight. The ventilator in the rear is not needed in the northern part of the country, but is desirable in the South.

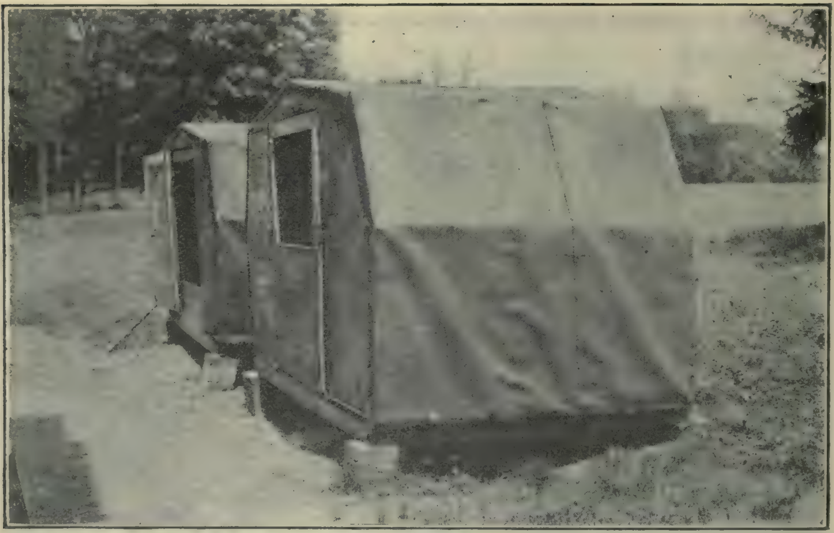

FIG. 5.—Poultry houses, each of which is made out of two piano boxes. The two boxes are placed back to back, 3 feet apart, the back and top of each removed, a frame for roof and floor added, and the part between the two boxes built in with the boards removed from the boxes. The whole is covered with roofing paper. With piano boxes at $3 each, such a house can be easily and quickly constructed for $12.50. It will accommodate 12 hens comfortably.

Such a house is large enough for a flock of 20 hens. It can be built quickly and easily and is cheap in construction. The material required is as follows:

BILL OF MATERIAL.

Framing.

Roof rafters and end plates, 5 pieces, 2 by 4 inches by 8 feet long.
Roof plates, 2 pieces, 2 by 4 inches by 8 feet long.
Sills, 4 pieces, 2 by 4 inches by 8 feet long.
Posts, 3 pieces, 2 by 4 inches by 6 feet long; 2 pieces 2 by 4 inches by 4 feet long.
Stringer, 1 piece, 2 by 4 inches by 8 feet long.
Total pieces required to cut list:
- 7 pieces 2 by 4 inches by 16 feet long.
- 1 piece 2 by 4 inches by 12 feet long.
  - Total feet in board measure, 83.

Roosts and Dropping Board.

1 piece 2 by 3 inches by 16 feet long.
1 piece 2 by 3 inches by 10 feet long.
Total board measure, 13 feet.
2 pieces 1 by 12 inches by 16 feet long.
Total board measure, 32 feet.

Sheathing Boards.

Roof, 5 pieces 1 by 12 inches by 16 feet long.
Two sides, 2 pieces 1 by 12 inches by 10 feet long; 3 pieces 1 by 12 inches by 12 feet long; 2 pieces 1 by 12 inches by 14 feet long.
Front, 2 pieces 1 by 12 inches by 10 feet long.
Back, 2 pieces 1 by 12 inches by 16 feet long.
Total feet in board measure, 216.

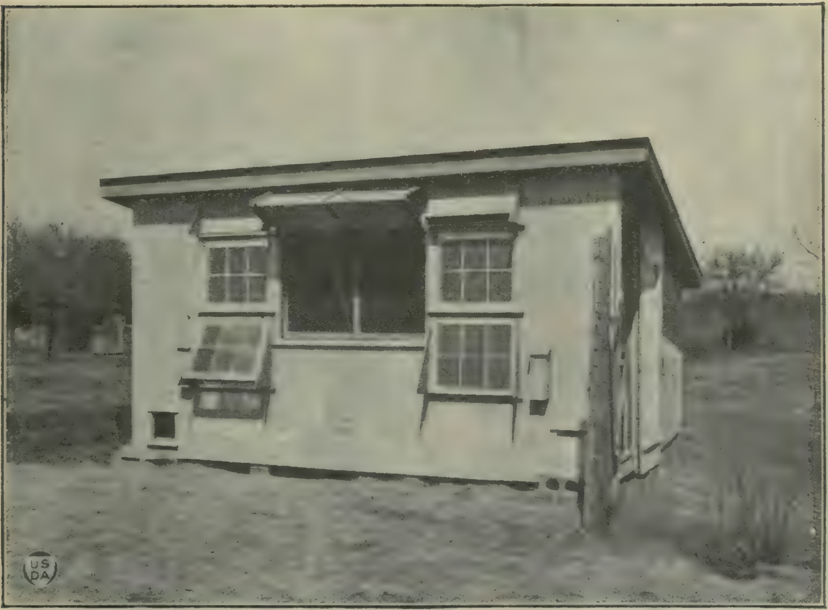

Fig. 6.—Good type of simple shed-roof house for a moderate-sized poultry flock in the suburbs.

Batten Strips.

130 linear feet ½ by 2 inch strips, 24 board feet.
24 linear feet ⅞ by 2 inch strips, for curtain frame, 4 board feet.

Roofing.

80 square feet roofing paper; nails and tins.

Hardware and Sundries.

1 pair 8-inch T hinges for door.
1 padlock and latch for door.
3 pairs 4-inch T hinges for curtain frame and rear ventilator.
5 pounds 10-penny wire nails for framing.
10 pounds 8-penny wire nails for sheathing.
5 pounds 4-penny wire nails for stripping.
21 square feet poultry wire, ¾-inch mesh, for front.
3 yards muslin for curtain.
32 rough bricks to build piers.

Floor.

If floor is desired in house, add the following material:

2 pieces 2 by 4 inches by 16 feet long.
4 pieces 1 by 12 inches by 16 feet long.
Total feet in board measure, 85.

Total Lumber Required.

Without floor, 372 board feet.
With floor, 457 board feet.
Lumber may be rough or dressed.

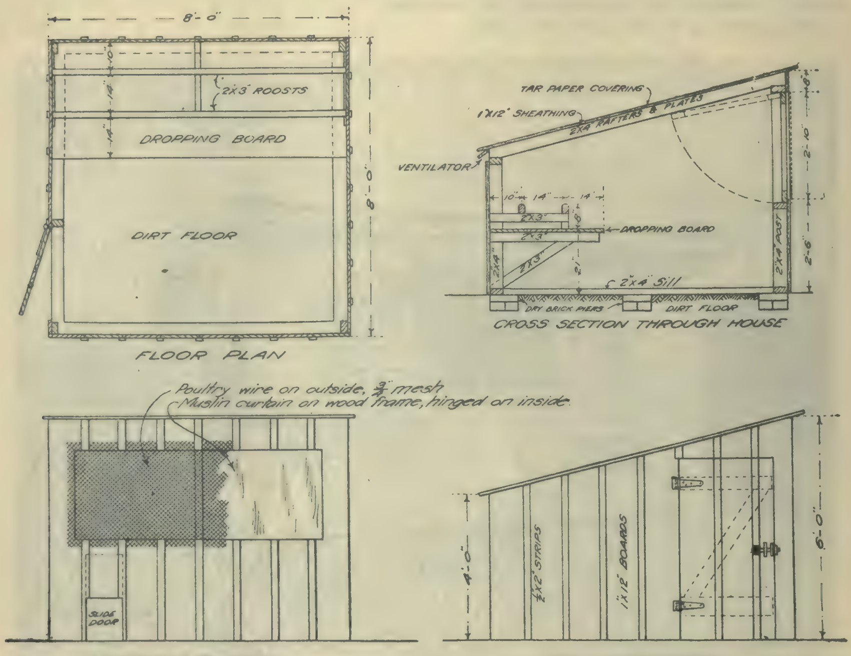

Fig. 7.—Plan of a simple back-yard poultry house.

Floor.—If the soil is light and sandy and is always dry no floor need be used in the house. The floor should be filled up several inches above the outside ground level. A dirt floor is hard to keep clean, and if there are many buildings near by it is difficult to keep rats from being troublesome with such a floor. A dirt floor also makes the house very dusty and it can not be kept so clean as a house with a wooden floor. Three or 4 inches of the surface of the floor and a thin layer of the soil of the run, if a very small run is used, should be removed and replaced with fresh dirt two or three times a year. A board floor is the most practical type of floor for most small poultry houses, as it is absolutely dry and is easy to keep clean. A concrete floor may also be used but is more expensive and is not so desirable in the small poultry house, as it may be necessary sometimes to move the house. A house with a board floor should be set on posts or blocks so that it is from 5 to 12 inches above the ground. When this space is left the floor will not rot so quickly and rats are not so likely to take refuge under the house. (See Fig. 8.)

Dropping boards and roosts.—To keep the flock in a clean and sanitary condition, dropping boards should be provided under the roosts. This makes it easy to remove the droppings each morning and helps greatly to keep the house free from objectionable odors. A little sand or ashes sprinkled on the dropping board after each cleaning will make the cleaning easier.

The dropping boards and roosts should be placed against the back wall. Here they are out of the way and also are least likely to be reached by drafts. The dropping boards should be about 20 to 30 inches from the floor, depending on the height of the building. This gives space enough under them so that the hens have room to exercise and is not too high for the heavier hens to fly up to. The roosts should be 3 or 4 inches above the dropping boards. If more than a single roost is used, they should be on the same level; otherwise all the hens will try to crowd upon the highest roost. A piece of 2 by 4 or 2 by 3, laid on edge and with the upper corners rounded off, makes a good roost. A pole, or even a piece of board 2 or 3 inches wide, may be used. If the roost is of light material and fairly long, it should be supported in the center, as well as at the ends, to prevent it from sagging badly. An allowance of 7 to 10 inches of roost space per fowl, according to the size of the birds, should be made. If more than one roost is used, they should be placed about 15 inches apart.

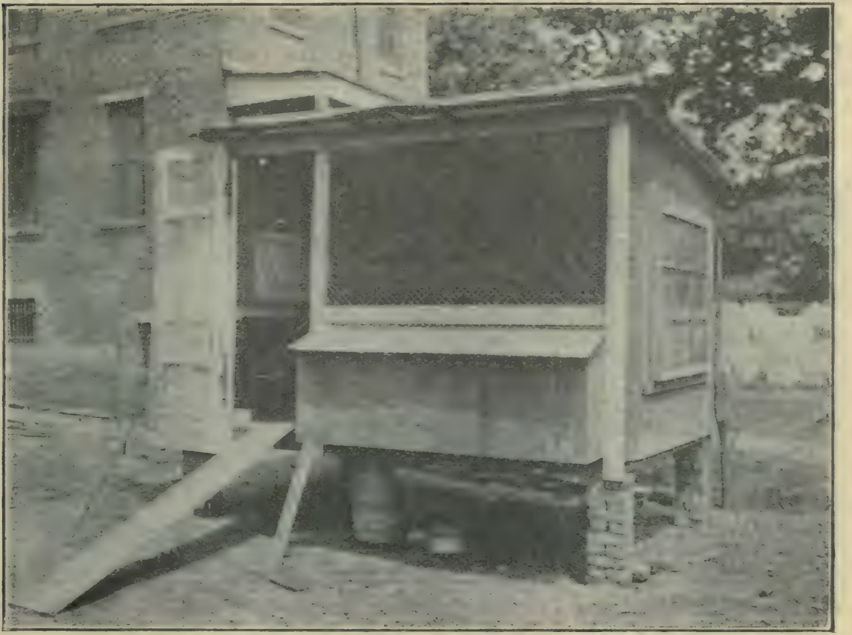

FIG. 8.—A good type of open-front poultry house for a small flock. The front can be closed with a muslin curtain on cold nights. The house is set on brick piers so as not to afford a refuge for rats. Notice the nests built out on the front of the house where the eggs can be reached by raising the hinged cover.

Nests.—Nests must be provided and may be very simple. Any box about 1 foot square and 5 or 6 inches deep is suitable. An ordinary orange box with the partition in the middle serves very well, each box forming two nests. The top is removed, the box laid on its side, and a strip 3 to 4 inches wide nailed across the lower front. (See Fig. 11.) Nests can be fastened against the walls of the house or set on the floor. It is preferable to fasten them against the wall, as they take too much floor space if set on the floor. One nest should be provided for each 4 or 5 hens.

The straw or other material used in the nest should be kept clean and not be allowed to get so low that the eggs when laid by the hen will strike the board bottom of the nest, as this will cause them to break and will start the hens to eating the eggs, which is a very troublesome habit and one that is difficult to break up once it is formed.

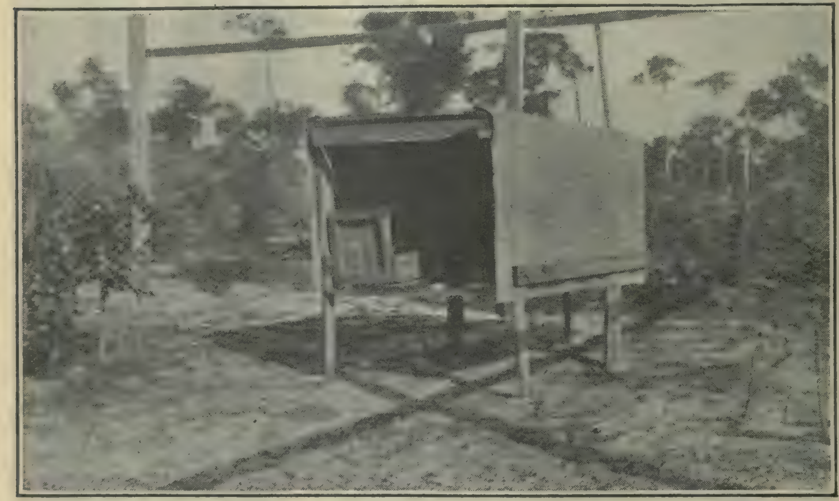

FIG. 9.—Shelter suitable for 4 or 5 hens, consisting of a lumber framework covered with roofing paper. This shelter has no floor and is provided only with roosts and nests. It is especially adapted for back yards in southern parts of the country.

Litter.—A litter of straw or the leaves raked up in the fall, about 3 or 4 inches deep, should be used on the floor of the house. This material helps to absorb the droppings and also provides a means of feeding the grain in such a way that the hens are obliged to exercise by scratching for it. Leaves are not nearly so desirable as straw, as they break up very quickly and make dirt and dust.

Coops for broody hens.—When hens become broody, they should be "broken up" as quickly as possible, for the sooner this is done the sooner they will resume laying. To break a hen of broodiness she should be confined to a small coop raised off the ground, preferably with a slat bottom. Give her plenty of water to drink, and one daily feed of a light mash. Usually from 3 to 6 days' confinement will break her, but some hens require 10 to 12 days. The broody hen will be recognized by her inclination to stay on the nest at night, the ruffling of her feathers and her picking at any one who approaches her, and by the clucking noise she makes. The fact that her broodiness has been broken up can be recognized by the disappearance of these symptoms.

THE YARD.

The yard should be inclosed by a wire fence. If cats prove troublesome where young chickens are being raised, it may be necessary to cover the top of the yard with wire netting. A board should not be used at the top of a wire fence, as this gives the hens a visible place to alight and tends to teach them to fly over. A 5-foot fence is high enough for most conditions. It is desirable to clip the flight feathers of one wing of all except the heavy breeds of fowls to prevent them from flying over the fence. Fowls to be used for exhibition must not be clipped, and higher fences may be necessary in that case.

The larger the yard which can be provided the better the hens will do, as it not only gives them greater opportunity to exercise, but also makes it possible to maintain a sod on the yard. In most cases not enough land will be available so that a sod can be maintained.

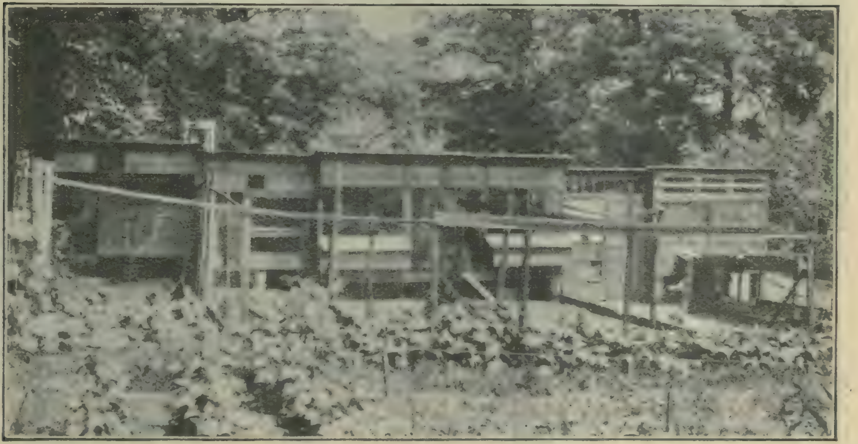

Fig. 10.—A larger poultry house suitable for a suburban lot. Notice the old lumber, sash, etc., used in the construction. The utilization of such used material, which can often be purchased for a small sum at auction or where buildings are being wrecked, lessens the cost of the poultry buildings very materially.

If the yard is fairly large, it can be divided into two parts and green crops, such as oats, wheat, rye, or dwarf Essex rape, allowed to start in one yard while the hens are confined to the other. (See Fig. 12.) The green crops should be sown very thick, and the following quantities will be found satisfactory for a yard 25 by 30 feet: Wheat, 2¾ pounds; oats, 1½ pounds; rye, 3¼ pounds; rape, 5 ounces. When the growing stuff reaches a height of 2 or 3 inches the hens can be turned upon it and the other yard be similarly sown.

Where it is inadvisable to divide the yard, it is possible to keep a supply of green stuff growing by using a wooden frame 2 or 3 inches high, covered with 1-inch-mesh wire. A frame made of 2 by 4 lumber, 6 feet long and 3 feet wide, with an additional piece across the center to support the wire when the hens stand on it, will be found desirable for a small yard. (See Fig. 13.) A part of the yard as large as this frame is spaded up and sown, the frame placed over it, and the material allowed to grow. As soon as the green sprouts reach the wire the hens will begin to pick them off, but since they can not eat them down to the roots the sprouts will continue to grow and supply green material. This frame can be moved from place to place in the yard, and different parts cultivated.

The yard should be stirred or spaded up frequently if not in sod. This will not only tend to keep down any odors which might arise, but also allow the droppings to be absorbed into the soil more readily and therefore keep the yard in better condition for the hens.

Although it is necessary to keep the hens confined to their yard most of the time, it is sometimes possible to let them out where they may range upon the lawn for an hour or so in the evening when some one can be at hand to watch them, or at certain seasons of the year to allow them to run in the garden plot. This will be enjoyed greatly by the hens and will be very beneficial to them.

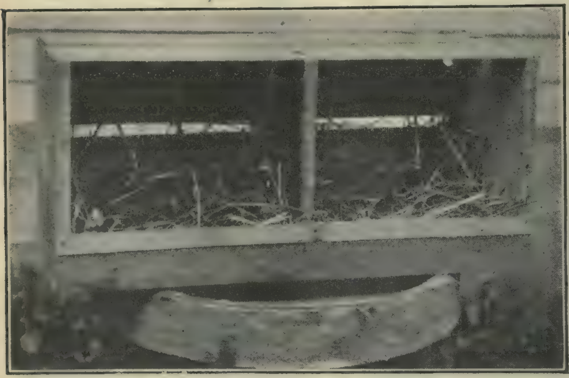

FIG. 11.—An orange box converted into a double nest by laying it on its side and nailing strips across the front to hold the nesting material in.

FEEDING.

The small flock kept in the village or city back yard should be given a light feed of starch grains in the litter early in the morning, kitchen garbage or table scraps at noon, and a good feed of scratch grains late in the afternoon. If it is more convenient to feed the table scraps in the morning, they may be fed at that time, with a very light feed of scratch grains and no feed given to the hens at noon. Feed three or four times as much grain in the afternoon as is feed in the morning, and always be sure that the fowls go to roost with a full crop, especially in the winter, when the nights are long and cold.

It is often advisable to mix a small quantity of dry or moist mash with the table scraps unless one has a very abundant supply of waste products. When the family's table waste is not sufficient for feeding the flock, it is usually possible to get some of the neighbors who keep no hens to save material suitable for feeding. Keep dry mash before the hens part of the day, opening the dry-mash hopper at noon and leaving it open until they are fed the following morning. This method of feeding provides the hens always with sufficient feed but keeps them hungry during the early part of the day so that they will clean up all the table scraps available. Feed the scraps in troughs, preferably on a feeding board, especially in summer, or at least use some method whereby the troughs in which the scraps are fed and the place around them may be kept absolutely clean. This is very important because when the waste products which the fowls do not eat get mixed with the ground the material decays and causes insanitary conditions which may result in heavy mortality in the flock.

Any waste milk should be mixed with garbage and mash. Be sure that the table or kitchen scraps are in good condition and do not contain any decayed meat or a large quantity of salt or salty meat, as these products are especially injurious to fowls. If more waste products are available than are readily eaten by the fowls it may pay to put these products through a meat or feed chopper to get them into a more palatable form so that the fowls will consume a larger quantity. With the exception of small potatoes, which should be boiled, vegetables and feeds do not need to be cooked for poultry.

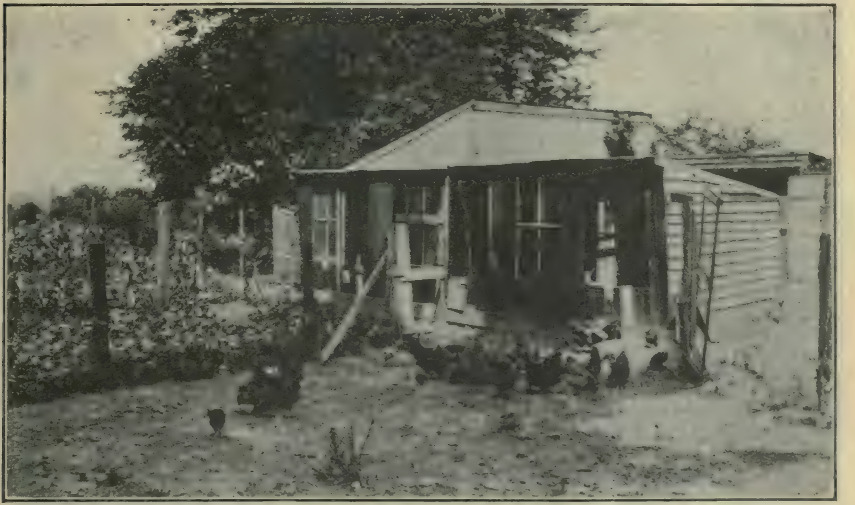

FIG. 12.—Back-yard poultry house and flock. Notice the double yard. The green crop of the first yard has been fed off and the second yard is planted to rape, which is about ready to feed.

Rations.—A balanced ration consists of the waste table scraps fed with a good grain mixture and a mash.

A good dry mash is composed of 2 parts by weight of corn meal and 1 part each of wheat bran, wheat middlings, and meat scrap.

Another good mash is composed of 1 pound of wheat bran, 1 pound of wheat middlings, 6.5 pounds of meat scrap, and 16.5 pounds of corn meal. The meat scrap used in the dry mash is usually the most expensive ingredient, but it is an essential part of the mash and is very efficient for egg production. It should not be eliminated or reduced unless the quantity of the meat in the table scraps is considerable or unless some other product can be substituted for it. Fish scrap, tankage, or dried milk may replace the meat scrap, or cottonseed meal may be used to replace half the meat scrap in the mash. No attempt should be made to replace more than half the meat scrap with cottonseed meal, as the results in egg production and in the quality of the eggs will be unsatisfactory.

A third good mash is composed of 1 part bran, 1 part middlings, 3 parts corn meal, 1½ parts meat scrap, 2 parts ground oats, with 5 pounds of linseed meal added to every hundred pounds of this mixture.

Two or more grains may be bought for the scratch feed, or a commercial scratch feed may be used. Be sure that the grain is of good quality and in good condition. Commercial mash feeds may be purchased, or the separate feeds may be bought and the mash mixed at home. Wherever sufficient feed is used to make it worth while to mix in half-ton or ton lots and a good place is available to store the feed, it may be found cheaper to mix the rations than to buy the commercial mixtures. A good grain mixture is composed of 2 parts by weight of cracked corn and 1 part oats. Another suitable grain mixture for this purpose is composed of equal parts by weight of wheat, cracked corn, and oats.

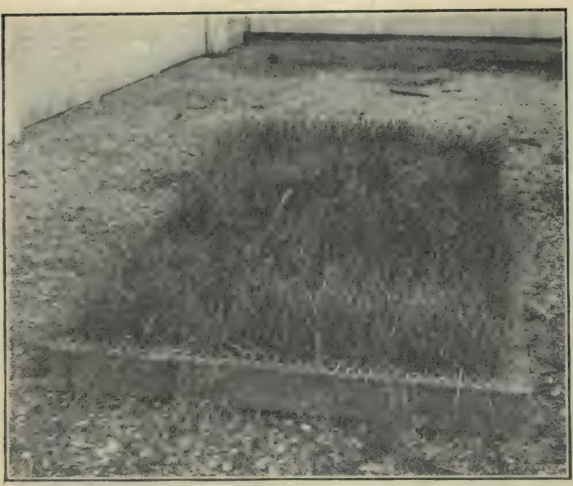

FIG. 13.—A frame made of 2 by 4 inch lumber and covered with ¾-inch-mesh poultry wire used to sprout oats or other grain for the hens. The wire prevents the hens from eating the sprouts down so close as to kill the plants and from scratching out the roots. Grain which is sprouted without protection will be quickly killed.

A good commercial mash should contain a protein content of 15 to 20 per cent, carbohydrates 50 to 60 per cent, and fat 4 to 6 per cent, with crude fiber not exceeding 6 to 10 per cent. A good general scratch mixture should contain about the following: Protein, 8 to 10 per cent; carbohydrates, 60 to 70 per cent; fat, 2 to 4 per cent; fiber not exceeding 5 per cent. It should always be remembered that the analysis is not the only consideration, as the kind and quality of feed should also be carefully considered. Unless the feeds are well relished and palatable to the fowls and are also of good quality they will not give good results, regardless of their analysis. The feed should not be musty and should be free from moldy or shriveled grains.

Green feed.—Green and succulent feed should be provided. During the growing season a large supply is usually available, consisting of weeds and waste vegetables from the garden and fresh lawn clippings. The latter may also be dried or cured and stored in bags or otherwise saved until winter, when they can be soaked in warm water and fed in that condition or mixed with some of the mash or table scraps. During the summer and fall any part of the garden not used for vegetables may be sown in oats or rye and this growing green feed cut when it is from 3 to 6 inches high and fed to the hens or to growing chickens. Where double yards are used considerable green feed can be supplied to the fowls by sowing grain four times during the year in whichever yard is vacant, alternating these yards and allowing the fowls to range on this green feed when it is from 2 to 4 inches high. Cabbages and mangel beets may be raised for use during the winter. Sprouted oats should be provided if no other green feed is available.

Oyster shell and grit.—Oyster shell, grit, and charcoal should always be kept before the fowls.

Quantity to feed.—The quantity of grain to feed depends largely on how much table scrap is available. It pays to give plenty of feed, as the extra eggs produced from good feeding are the ones which really return a profit. Many back-yard flocks are underfed. A light feed of grain, about two-thirds of a pint to 25 hens, in the morning is all that is necessary when considerable table scrap is fed during the day, but a heavy feed of grain, about 2½ pints to 25 hens, should be given at night. By scattering this grain in the litter on the floor the hens will be compelled to scratch in order to find the grain, and in this way to take exercise, which is decidedly beneficial to them. In addition, dry mash should be kept before them. If only a small quantity of table scrap is used, so that the hens eat it up quickly, the dry-mash hopper should be kept open all the time and more grain fed.

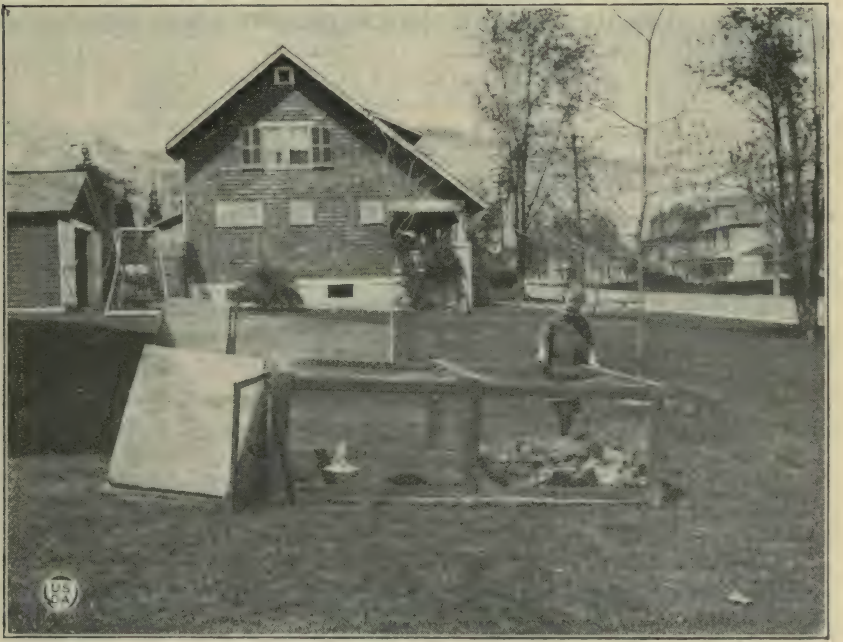

FIG. 14.—Inclosure for hen and chicks with box used as a coop at the end. Both coop and run are moved each day to a fresh spot of ground.

Water.—A plentiful supply of clean, fresh water must always be available. The fowls drink freely, especially when laying heavily. The water pan or dish should be kept clean. If it is not washed out frequently a green slime will gather on its inner surface. It is well to keep the water pan outside the house in the shade in summer, but in freezing weather it is best to keep the pan in the house and to empty it each night. It should be raised about a foot above the floor so that the hens will not scratch litter into it.

Use of artificial light.—Artificial lights help stimulate egg production from pullets in the fall and winter when eggs are highest in price. Where electric lights can be installed at small expense, they are worth considering when 50 or more pullets are kept. Ordinarily the back-yard poultry keeper would not have a sufficient number to make the cost of installing electric lights worth while.

LICE AND MITES.[2]

Dust bath.—If the best results are to be expected from the flock, the hens must not be allowed to become overrun with lice or the house with mites. Usually there is a place in the yard where the hens can dust themselves in the dry dirt. In the absence of such a place, a box about 2 feet square and containing ordinary road dust or fine dirt should be placed in the house. A dust bath aids the hens in keeping lice in check and adds to their comfort. If they are not able to keep them in check by dusting themselves, other measures can be taken.

Lice.—To rid the hens of lice, each one can be treated by placing small pinches of sodium fluorid, a material which can be obtained at most large drug stores, among the feathers next to the skin—one pinch on the head, one on the neck, two on the back, one on the breast, one below the vent, one at the base of the tail, one on each thigh, and one scattered on the underside of each wing when spread. Two applications a year are sufficient.

Mites.—Mites are more troublesome and more harmful than lice. They do not live upon the birds, like the lice, but during the day hide in the cracks and crevices of the roosts and walls of the house, and at night they come out and get upon the fowls. They suck the hen's blood, and if allowed to become plentiful—as they certainly will if not destroyed—will seriously affect her health and consequently her ability to lay eggs. They may be eradicated by a few thorough applications of kerosene or some of the coal-tar products sold for this purpose, or crude petroleum, to the interior of the poultry house. The commercial coal-tar products are more expensive but retain their killing power longer, and the cost of treatment may be lessened by reducing with an equal part of kerosene. Commercial carbolineum, which consists essentially of a high-grade anthracene oil derived from coal tar, has proved very effective. The killing power of this substance lasts for several months, and mites which may be inclined to come in from other buildings are repelled for a long time. Crude petroleum will spray better if thinned with 1 part of kerosene to 4 parts of the crude oil. Both the crude petroleum and the coal-tar products often contain foreign particles, so should be strained before attempting to spray. One must be sure that the spray reaches all the cracks and crevices, giving especial attention to the roosts, dropping boards, and nests, and the treatment should be repeated two or three times at intervals of a week or 10 days.

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[2] For further information on the subject of poultry lice and mites and their control the reader is referred to Farmers' Bulletin 801, Mites and Lice on Poultry, by F. C. Bishopp and H. P. Wood, of the Bureau of Entomology. Copies of this bulletin may be obtained free on application to the Division of Publications, United States Department of Agriculture.

HATCHING AND RAISING CHICKS.

Where it is advisable to attempt to renew the poultry flock by hatching and rearing chicks, or by purchasing and rearing day-old chicks, previous experience in the raising of chickens increases the chances of success. However, the land available is usually small in area, and it is not advisable to raise chicks unless a plot can be provided separately from that to which the hens have access, and upon which there is grass, or unless a supply of green feed can be furnished. Where these conditions do not exist, it is better to kill the hens as soon as they have outlived their usefulness and replace them by well-matured pullets in the fall. Where it is found desirable to hatch and rear a few chicks this can usually be done best with hens. When day-old chicks are purchased to rear and no hens are available for the purpose a stove brooder or hovers may be used. A stove brooder is profitable if 200 or more day-old chicks are bought or hatched at one time, but for smaller flocks the hovers are preferable. Full directions for brooding chickens are given in Farmers' Bulletin 624.[3]

The hatching should be done early in the spring and be completed if possible by the first of May. Chicks hatched before that time will have a good chance to be in laying condition before the cold weather sets in and should be producers during the entire fall and winter. Early hatched chicks are also easier to raise, as they live and thrive better than those which are still small when the hot weather begins. Persons desiring to hatch and raise chicks are referred to Farmers' Bulletins 585, Natural and Artificial Incubation of Hens' Eggs, and 624, Natural and Artificial Brooding of Chickens.[3]

CULLING THE HENS.

In any flock some hens will be found to be much better producers than others. Often there are a few hens which are such poor producers that they are unprofitable. The owner often is able to determine the poor layers by observation. These should be the ones to eat.

As a rule hens of the general-purpose breeds are not profitable layers after they are 2 years old, and Leghorn hens rarely lay profitably after three laying years. Many of the hens should be culled before they reach these ages.

All hens molt in the fall or early winter. During this molting season, which usually takes about three months, the hens lay few or no eggs. It is advisable, if well-matured pullets can be purchased at a reasonable price, to kill and eat the hens as they begin to molt, replacing them with pullets. The hens should not be killed, however, until they begin to molt and their combs begin to lose size, color, and flexibility, for if these changes have not taken place the hens will probably still be laying when eggs are especially valuable.

Detailed directions how to cull out the hens which are not laying are given in Farmers' Bulletin 1112, Culling for Eggs and Market.

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[3] Copies of these publications may be obtained free from the Division of Publications, United States Department of Agriculture.

PRESERVING EGGS.

Where a large flock is kept, there will be a time during the spring and early summer when more eggs are produced than are used. These surplus eggs can either be sold or, what is perhaps more desirable, preserved in the spring for home use during the fall and early winter, when eggs are high in price and much more difficult to obtain from the flock.

The eggs to be preserved must be fresh. They should be put into the preserver on the day on which they are laid. The eggs should be clean, but it is better not to wash them. Eggs with dirty shells can be used for immediate consumption and the clean eggs preserved. Cracked eggs or those with thin or weak shells should never be used for preservation. Not only will the cracked egg itself spoil, but it will cause many of the other eggs packed in the same jar to spoil.

Water glass.—One of the best methods of preserving eggs is by the use of water glass. This can be purchased from the druggist or poultry-supply men. It is a pale yellow, odorless, sirupy liquid. It should be diluted in the proportion of 1 part of water glass to 9 parts of boiled water which has cooled. Earthenware crocks or jars are the best containers for the purpose, since they have a glazed surface and are not subject to chemical action from the solution. Galvanized ash cans or large pails are suitable for preserving eggs with water glass but do not work satisfactorily with limewater. The crocks or cans should be scalded out, so that they will be perfectly clean, and allowed to cool before they are used. A 6-gallon container will accommodate 18 dozen eggs and will require about 22 pints of solution. Too large containers are not desirable, since they increase the liability of breaking some of the eggs. Half fill the container with the water-glass solution and place the eggs in it. Eggs may be added from day to day until the container is filled. Be sure that the eggs are covered with about 2 inches of water-glass solution. Cover the container and place it in a cool place, where it will not have to be moved. It should be looked at from time to time to see that not enough of the water has evaporated so that the eggs are too near the surface. If there seems to be any danger of this, sufficient cool boiled water should be added to keep them covered.

Remove the eggs from the solution as desired for use and rinse them in clean, cold water. Before boiling such eggs prick a tiny hole in the large end of the shell with a needle, to keep them from cracking. As the eggs age the white becomes thinner and is harder to beat. The yolk membrane becomes more delicate, and it is correspondingly difficult to separate the whites from the yolks.

Limewater.—Limewater is also satisfactory for preserving eggs and is less expensive than water glass. A solution is made by placing 2 pounds of unslaked lime in 5 gallons of water which has been boiled and allowed to cool, and allowing the mixture to stand until the lime settles and the liquid is clear. The eggs should be placed in a clean earthenware jar or other suitable vessel and covered to a depth of 2 inches with the liquid. Remove the eggs as desired, rinse in clean, cold water, and use immediately.

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U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1332

SEED POTATOES AND HOW TO PRODUCE THEM

THE AVERAGE PRODUCTION per acre of potatoes in the United States is very much lower than in Canada, Great Britain, and European countries outside of Italy.

One of the reasons for the lower production in the United States is that less attention has been given to the character of the seed. Good seed is one of the determining factors in the production of maximum crops of potatoes.

The use of high-grade seed would increase the returns from the potato crop of the country by many millions of dollars.

The quality of the seed may be improved through the removal of all diseased, weak, or off-type plants as soon as they are observable.

Only seed from productive plants should be used.

Careful attention should be given to securing seed that is free from varietal mixture and that is true to type.

Good seed can not be produced unless the growing plants are given good cultural attention.

As a rule the quantity of seed used is not sufficient to produce a maximum crop.

From 15 to 18 bushels of seed should be used per acre instead of 9 to 11, as at the present time.

All seed stock should be disinfected before planting.

Good storage conditions are essential to insure sound, firm seed at planting time.

This bulletin is a revision of and supersedes Farmers' Bulletin 533, Good Seed Potatoes and How to Produce Them.

Washington, D. C. Issued May, 1923; revised May, 1925

SEED POTATOES AND HOW TO PRODUCE THEM.

By WILLIAM STUART, *Horticulturist, Office of Horticultural Investigations, Bureau of Plant Industry.*

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YIELDS OF POTATOES.

A STUDY of the statistical data upon potato crop production in the United States for the last 55 years[1] reveals the interesting fact that relatively little gain in production per acre has been made during this period. To partially minimize seasonal variations in yield per acre the 55-year period has been divided into eleven 5-year cycles and the average production of each cycle compared. During the first 5-year cycle, 1868–1872, the average yield per acre was 94.5 bushels, while in the last 5-year period it was 98.9, or a gain of approximately 4.4 per cent. The averages for the eleven 5-year cycles are 94.5, 88.1, 77.9, 76.7, 74.0, 79.9, 82.2, 96.3, 96.5, 96.0, 98.9 bushels per acre, respectively. A study of these data shows that there was a very appreciable and more or less gradual decline in production per acre during the second, third, fourth, and fifth cycles, or from 1875 to 1892, inclusive, and that during the next three cycles there was a decided increase, the fifth cycle showing a slight increase over the first cycle. From this period until 1908 to 1922 the increase has been a very nominal one, unless we choose to regard the 1918 to 1922 performance as indicating a permanent improvement in the per acre production of potatoes. From the data presented it is evident that the slight gain in average yield per acre (4.4 per cent) in the last of the eleven 5-year cycles over that of the first cycle is not sufficient to account for the increased production of potatoes in the United States. The total average bushel production in the United States for the years 1868 to 1872 was 117,745,800, while in the last 5-year period (1918–1922) the average production was 390,615,600 bushels, or an increase over the first period of more than 231 per cent. During this same period the increase in acreage devoted to potato production has been more than 217 per cent. These data show conclusively that increased production in the United States during the last 55 years has been almost entirely due to increased acreage rather than to any material improvement in cultural practices resulting in larger yields per acre.

Table 1 and the accompanying diagrams (figs. 1 to 3) show the average acre yields, the farm price per bushel, the acreage grown, and the total production of potatoes, while Figure 4 shows the population of the United States during the eleven 5-year cycles studied. In the construction of these diagrams it has not been feasible to employ the same scale in any two of them, owing to the great difference in the magnitude of the figures treated. A careful study of the first diagram (fig. 1), in which the acreage yield and farm price per bushel are given, shows that the acreage-production curve, if drawn on the chart, would somewhat resemble the curve of a scimitar blade, in which the extreme ends of the blade represent the maximum yields for each half of the curve.

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[1] The statistical data upon which these studies are based were obtained for the years 1868 to 1888 from the United States Department of Agriculture Yearbook for 1917, p. 657; for 1889 to 1895 from the 1920 Yearbook, p. 617: for 1896 to 1920 from the 1921 Yearbook, p. 583; and for 1921 to 1922 from the December 23, 1922, issue of the United States Department of Agriculture Weather Crops and Markets publication, p. 565.

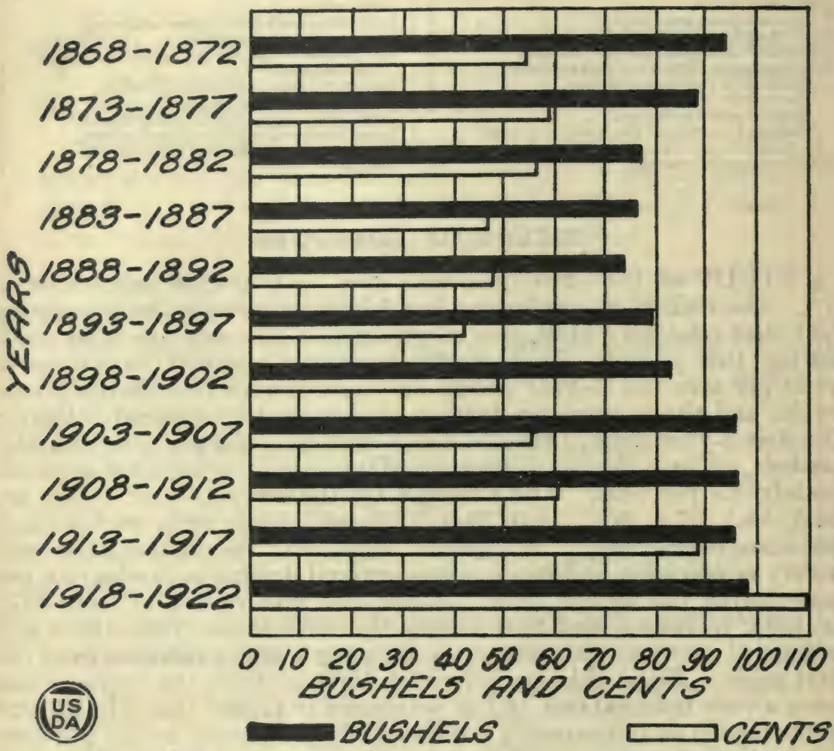

FIG. 1.—Diagram showing the average number of bushels per acre and the average farm price per bushel of potatoes grown in the United States by 5-year periods from 1868 to 1922.

TABLE 1.—*Averages of acreage, production, and farm values of potatoes in 5-year periods from 1868 to 1922, inclusive.*

5-year period.	Number of acres.	Production (bushels).		Farm value on Dec. 1.	
		Total	Per acre.	Total.	Per bushel (cents).
1868 to 1872	1,246,200	117,745,800	94.5	$64,123,600	54.5
1873 to 1877	1,529,800	134,773,200	88.1	68,665,600	50.9
1878 to 1882	1,934,200	150,706,200	77.9	85,547,200	56.8
1883 to 1887	2,284,000	175,197,800	76.7	82,295,000	46.9
1888 to 1892	2,633,800	194,939,400	74.0	93,012,600	47.7
1893 to 1897	2,900,400	231,757,800	79.9	95,258,400	41.1
1898 to 1902	2,968,200	243,866,400	82.2	117,671,600	48.3
1903 to 1907	3,213,200	309,568,200	96.3	170,652,800	55.1
1908 to 1912	3,644,400	351,793,800	96.5	213,038,200	60.6
1913 to 1917	3,812,400	366,045,600	96.0	322,292,400	88.0
1918 to 1922	3,948,400	390,615,600	98.9	425,975,400	109.1

The gradual decline in yields during the first half of this period is thought to be largely due to the following factors:

The ravages occasioned by the Colorado potato beetle during the early period of its invasion of the eastern United States.

The financial depressions of 1877 and 1893, which brought about a well-marked decline in agriculture in New England, New York, and the other heavy potato-producing areas of the northeastern United States.

A gradual depletion of soil fertility.

Of the factors which have checked the downward tendency and contributed most largely toward a return to the old production level the following are thought to have been most potent:

The influence of the agricultural experiment stations, agricultural colleges, and the United States Department of Agriculture through experimentations, demonstration, and the dissemination of literature.

The influence of the Bordeaux-mixture treatment in the control of fungous diseases affecting the potato.

The development of special potato-growing sections, as, for example, Aroostook County, Me., the Atlantic Coastal Plain trucking region, the Greeley and Carbondale districts of Colorado, and many other areas, in which the average yield is approximately from two to three times the general average for the United States.

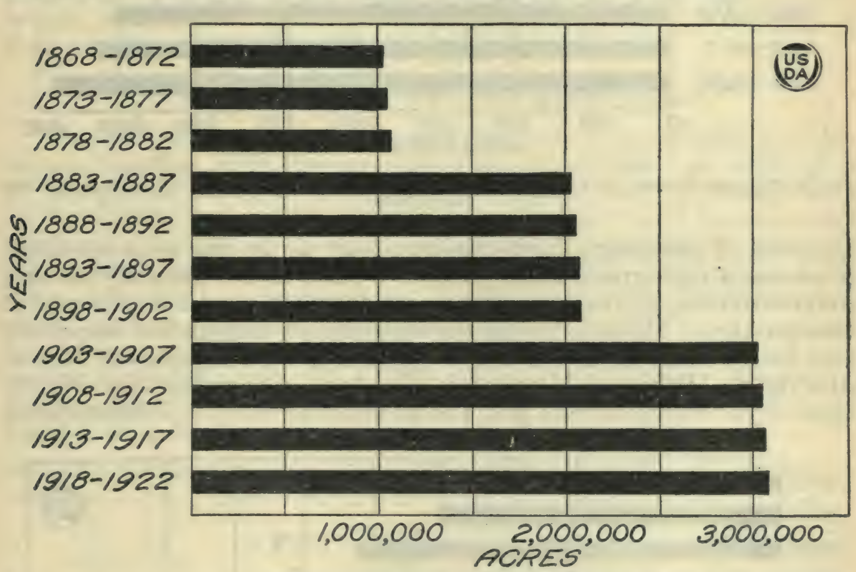

FIG. 2.—Diagram showing the average potato acreage of the United States by 5-year periods from 1868 to 1922.

Figures 1 to 4 show a comparison of the relation of increased production to a constantly increasing population. The diagrams show that under normal conditions production is keeping pace with population. Crop shortages are, therefore, the result of abnormal or unfavorable conditions.

In comparing the average crop production of potatoes in the United States with that of Great Britian, one is impressed with the fact that generally speaking we have much yet to learn before we can raise our average to that of that country. During the years 1901 to 1910, inclusive, the average acre yield in Great Britain was approximately 200 bushels, while that in the United States was not quite 93 bushels.

Of the many causes which produce a low average potato yield in this country, poor seed is thought to be important. The American potato grower pays too little attention to his seed potatoes. European growers pay very strict attention to the quality and quantity of seed they use. This has led to the differentiation of the potato growers into seed and crop specialists. The seed specialist makes a business of producing high-quality seed, while the crop specialist produces a high-grade table potato. Until rather recently no such differentiation, at least to any marked extent, could be claimed in this country. However, with the adoption of seed-potato inspection and certification in California, Colorado, Idaho, Kentucky, Maine, Maryland, Michigan, Minnesota, Montana, Nebraska, New Hampshire, New Jersey, New York, North Dakota, Oregon, Pennsylvania, South Dakota, Vermont, Washington, Wisconsin, Wyoming, and all of the Canadian Provinces, groups of seed-potato growers are gradually being evolved. A further stimulus to those who are engaged in the production of seed potatoes is the increasing demand for good seed stock at prices which are sufficiently remunerative to well repay the grower for the extra care given to the crop.

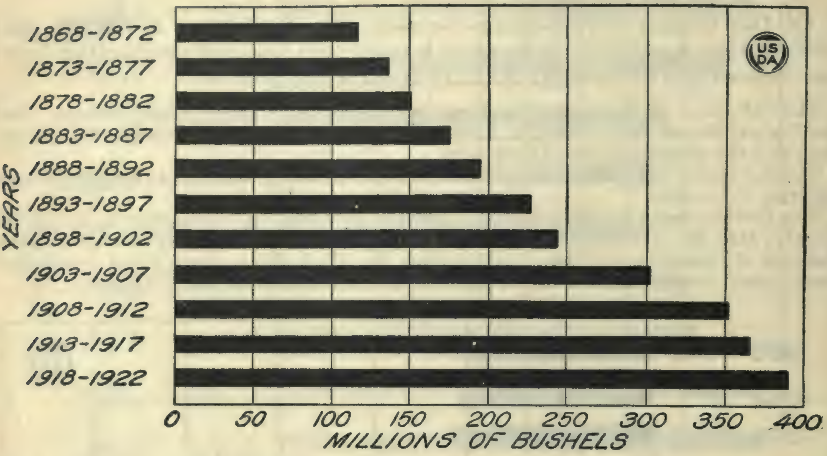

FIG. 3.—Diagram showing the average potato production of the United States by 5-year periods from 1868 to 1922.

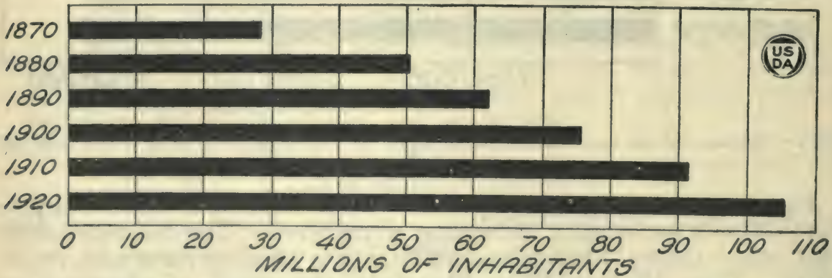

FIG. 4.—Diagram showing the population of the United States by decades from 1870 to 1920.

WHAT CONSTITUTES GOOD SEED.

Two factors are involved in the consideration of good seed potatoes: (1) The physical or outward appearance of the tubers and (2) the heritable or transmissible characters of the stock. The first involves the purity and maturity of the stock, uniformity in size and shape of the tubers, brightness of skin, firmness of flesh with first sprouts just showing, and freedom from scab, Rhizoctonia, late-blight, or other tuber-decay diseases. The second factor deals with nonobservable characters and is by far the more important one, as it involves the presence or absence of the virus diseases causing mosaic, leaf-roll, spindle-tuber, streak, and yellow dwarf. Freedom from the virus diseases is an important consideration and can only be assured through personal inspection of the growing plants from which the seed was obtained or by the purchase of reliably certified stock. If in any given year it were possible to plant the entire potato acreage of the United States with first-class seed stock the total production would be increased from 10 to 25 per cent. Based on the average production for the 5-year period from 1918 to 1922, this increase would represent from 39 to 97½ million bushels, or an increase in money value of $40,333,000 to $106,333,000.

CERTIFIED AND UNCERTIFIED SEED.

The rapid increase in acreage and production of certified seed potatoes, together with the premium over uncertified seed demanded by the grower for such stock, has made it necessary to demonstrate its superiority over ordinary seed. In the early and consequently developmental period of seed certification the producers' claims of superiority were not sufficiently well supported by experimental evidence to make them convincing. To-day there is abundant evidence of the general superiority of certified over uncertified seed potatoes. In a recent paper presented at the 1924 annual meeting of the Potato Association of America, H. C. Moore, of the Michigan Agricultural College, submitted data covering actual comparative tests by a large number of independent investigators, as shown in Table 2.[2]

TABLE 2.—*Comparative tests of potato yields, showing the advantage of using certified seed.*

Location of tests.	Number of tests or reports.	Average increase in yields per acre (bushels).	Location of tests.	Number of tests or reports.	Average increase in yields per acre (bushels).
Canada (8 Provinces)	15	88	Michigan	314	73
Connecticut	144	53	Missouri	46	43
Delaware	21	83	Montana	2	219
Indiana	9,740	44	Nebraska	64	141
Illinois	15	47	New York	68	76
Kansas	11	41	Ohio	168	48
Kentucky	220	42	Oregon	3	150
Louisiana	31	42	Pennsylvania	87	41
Maine	279	83	South Carolina	8	31
Massachusetts	....	75			

These and many other data serve to emphasize the value of high-grade seed. They also indicate the general superiority of certified over noncertified stocks as a source of good seed.

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[2] Moore, H. C. Evidence that certified seed is improved seed. *In* Proc. 11th Ann. Meeting, Potato Assoc. America, 1924, p. 28. 1925.

UNIFORMITY IN SIZE AND SHAPE OF TUBERS.

Under normal conditions of growth many present-day commercial varieties are very variable in size and shape of tuber. To some extent both size and shape are determined by the character of the soil, rate of planting, fertilization, and cultural care given the growing crop. Inheritance, however, plays a very important part. Most varieties contain within themselves distinct varietal strains which when isolated are much more uniform in respect to size and shape than the variety itself. Other things being equal, the variety or varietal strain that produces the greatest number of fair-sized shapely tubers and the smallest number of ill-shaped and small tubers should prove the most valuable, because it involves less waste to both the grower and the consumer. It is particularly important at present that such strains be developed, because there is an increasing demand for fancy table stock to satisfy the requirements of a large and discriminating class of consumers who are insisting on greater uniformity in size and shape and are willing to pay a premium on such grades.

DEVELOPMENT OF HIGH-GRADE SEED POTATOES.

The successful production of high-grade seed potatoes is very largely dependent upon the following factors: (*1*) *Starting with a good strain;* (*2*) *the proper treatment of the seed;* (*3*) *thorough preparation and proper fertilization of the soil;* (*4*) *the following of the best cultural practices, including protection against insect and fungous pests;* (*5*) *the elimination of all mixtures and all diseased or weak plants; and* (*6*) *the careful harvesting and proper storage of the crop.*

SECURING A GOOD STRAIN OF SEED.

If the strain of seed you are using is lacking in vigor, it is generally advisable to discard it and purchase a new lot from some reliable grower whose stock you have reason to believe is superior to yours. This suggestion is made as the result of a rather wide experience in trying to improve poor strains of potatoes through selection methods. Such attempts have usually resulted in failure, and it is felt that as a rule much more satisfactory progress can be made by starting with a new strain. Further improvement can usually be secured through selection.

SEED-POTATO IMPROVEMENT BY SELECTION.

The improvement of seed potatoes by selective processes has long engaged the attention of the potato grower. Recent experimental evidence seems to indicate that the possibilities of improving potato seed stock by selective processes alone are not as great as many writers upon this subject have claimed. To those who have devoted much time and effort to the improvement of the potato by selection it would appear that the chances of finding superior yielding true-to-type strains within a variety are not as great as has been believed. The chief advantages to be derived from seed-potato selection practices are the elimination of diseased and weak plants and the removal of varietal mixtures.

IMPROVEMENT PRACTICES.

Five improvement practices may be used in securing a high-yielding and commercially desirable strain of potatoes: (1) The tuber-unit method, (2) hill selection, (3) mass selection, (4) field roguing, and (5) strain testing.

In early editions of Farmers' Bulletin 533 considerable emphasis was laid upon the tuber-unit method of seed-potato improvement; subsequent experiences of the writer and others have indicated that this method is not as satisfactory or as practical in operation as the other four methods suggested. It is thought desirable, however, to briefly describe the tuber-unit method because some of its processes are applicable to other selection methods.

TUBER-UNIT METHOD.[3]

The tuber-unit method, as now generally understood, consists in selecting from the seed bin before planting time a considerable number of the most perfectly shaped tubers ranging from 6 to 8 ounces in weight. When planted, these tubers are quartered, as dropped, into four as nearly equal parts as possible, by splitting the bud-eye cluster twice from seed to stem end of the tuber. In other words, the tuber is cut through its longitudinal axis. The four pieces of each tuber are dropped consecutively in the row at a distance of from 10 to 12 inches apart in the furrow. All tubers showing discoloration of the flesh or other evidence of disease should be rejected. By allowing an additional spacing between each set of fours, the four plants from each tuber are definitely isolated from adjoining ones and the grower can readily observe any variation in vigor and uniformity between the various units planted. This method also enables him to detect any mixtures that may occur in the variety. All mixtures should at once be removed. By marking the units which appear to be the most uniform in size, vigor, and type when the plants are still in vigorous growth, the first step in selection has been accomplished. At digging time the product of each unit is separately harvested and a further selection made from the marked units of all tubers which most nearly approach the size, shape, and smoothness desired. The selected tubers of each unit should be separately placed in small sacks, preferably cotton or burlap, numbered with both field and unit numbers, and stored to await further examination. The final examination should produce data on the number and weight of merchantable and unmerchantable tubers and their general conformity in size, shape, and smoothness of the type desired. From each of the units retained 10 of the best tubers should be selected for the next season's planting.

It is desirable to maintain the study of each selection on the tuber-unit basis the following season, because it permits a more accurate comparison of the behavior of each. The 10 selected tubers from each original unit will give 40 plants for study the second year. All selections which do not produce a reasonably uniform lot of plants should be marked for rejection. At harvest time the progeny of each selection should be kept by itself and the same data recorded as those taken on the crop grown from the original tuber unit. Only the product from such 40-hill rows as meet the most rigid requirements should be retained. The further conduct of the work will consist in the multiplication of the selected strains for field planting and the elimination of weak plants.

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[3] For further information concerning the arrangement of a tuber-unit selection plat and a convenient system of note taking, see Stuart, William, The "tuber-unit" method of seed-potato improvement. U. S. Dept. Agr., Bur. Plant Indus. Cir. 113, pp. 25-31, 2 fig. 1913.

HILL SELECTION.

The hill-selection method consists in marking the most promising plants during the growing season and at harvesting time saving only those which give the greatest promise. (Figs. 5 and 6.) The progeny of each hill should be kept separate and the same data taken as outlined for the tuber unit. Plant on the tuber-unit or progeny-row basis the following season. For the sake of uniformity a definite number of tubers (five or more) should be planted from each hill selection. From this point on, follow the methods given in tuber-unit work.

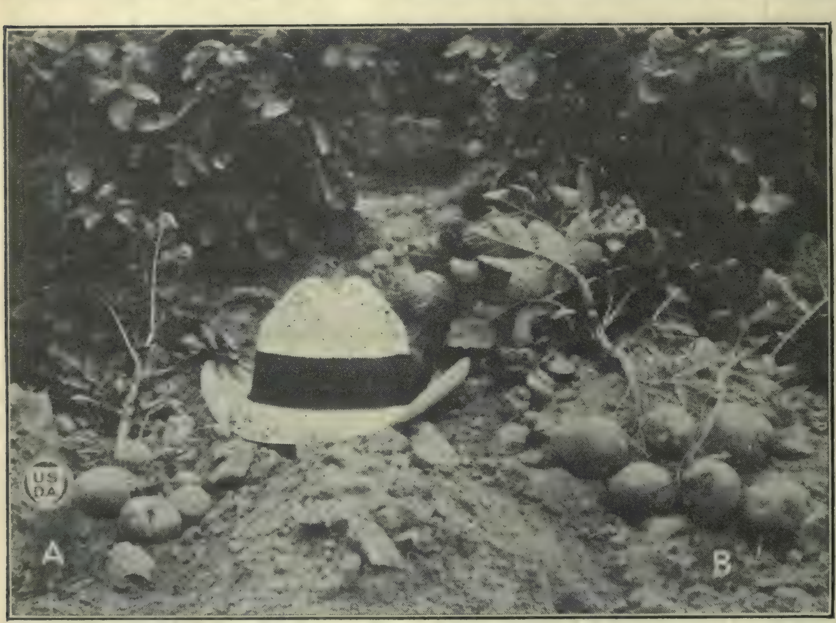

FIG. 5.—Progeny of a mosaic-infected potato plant of the Triumph variety on the left (*A*) and of a healthy plant on the right (*B*). Bin selection of such seed would result in taking at least two tubers from the mosaic plant. If small tubers were used all would come from diseased plants. In hill-selection work the progeny of plant B should be saved.

MASS SELECTION.

Mass selection differs from hill selection in only one respect, which is that the tubers from the individually selected plants are not kept separate. Generally those who practice mass selection do not go to the trouble of marking promising individual plants during the growing season, but simply go through the field before harvesting the whole crop and dig by hand as many plants as may be desired to secure the necessary quantity of seed that show the desired vigor and stem characters thought to be correlated with productiveness, trueness to type, and uniformity in size of tubers of the particular variety grown.

FIELD ROGUING.

Improvement of the seed stock through field roguing consists in the removal of all diseased, weak, off-type, or varietal-mixture plants during the growing season. The successful removal of such plants does not necessarily involve an intimate knowledge of the various diseases affecting the potato, but it does require that the person doing the roguing be able to tell whether a plant is normal or abnormal in appearance. A sufficient field area should be rogued the first year to provide the quantity of seed necessary to plant the full acreage to be grown the ensuing season. The area to be rogued should be gone over at least three times during the growing season, to insure the removal of all plants affected with transferable diseases, such as mosaic and leaf-roll, as soon as their presence can be detected. In the field-roguing method no attempt is made to select the progeny of individual plants at harvesting time, the whole crop being dug and all desirable seed stock gathered and stored in bulk.

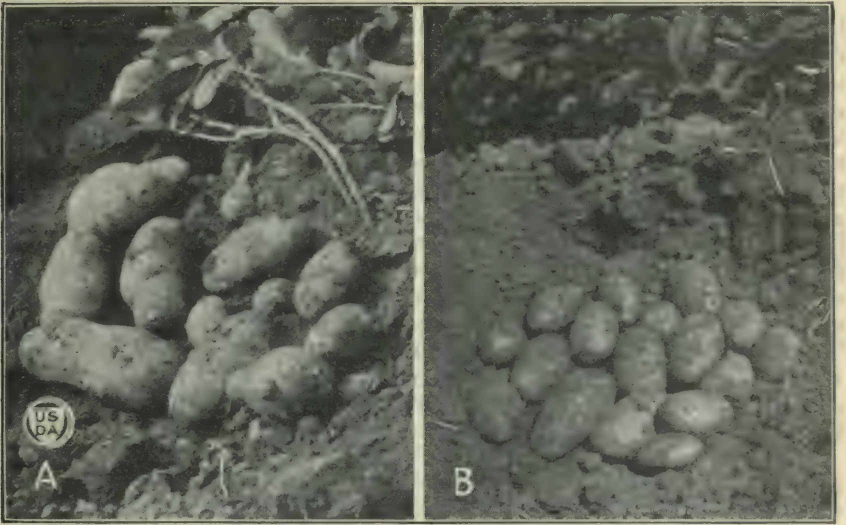

FIG. 6.—Progeny from abnormal (*A*) and normal (*B*) plants of the Russet Burbank potato. Plant A is known in the West as a degenerate or run-out plant, and the disease with which it is affected is probably identical with that recently termed "spindle tuber." It is a communicable disease and may become serious. In hill-selection work the progeny of plants such as *B* should be saved.

STRAIN TESTING.

The improvement of seed potatoes by the strain test, or, as it might more properly be termed, the "source-of-seed test" method, consists in securing as many as possible desirable lots of seed stock of the same variety from different growers throughout a given district or State, or even from various States, and carefully studying their behavior when grown side by side under identical soil and cultural conditions. Experimental studies by this method of seed improvement have demonstrated that some lots or strains of seed stock are far superior to others; in fact, differences in yield of more than 100 bushels per acre have been noted between the lowest and highest yielding strains. Furthermore, it has been conclusively demonstrated by numerous trials that these yields were not accidental, but that in practically every instance the high-yielding strains have consistently given larger yields wherever tested.

The improvement of seed stock by this method does not consist in the actual isolation and development of a strain from a given variety, but rather in locating, as it were, by comparative tests the really superior sources of seed stock. The actual improvement accomplished is measured by the success attending one's efforts in getting live, up-to-date growers to discard their inferior strains and purchase the superior one, as shown by the tests made.

The practical operation of such a movement may be best emphasized by stating that in 1921 over 100 potato growers in Wisconsin grew seed stock of a superior strain of Triumph potatoes located in this manner in 1918.

It should be remembered that whatever selection practice is pursued the fields devoted to the production of high-quality seed must be carefully rogued if the vigor of the seed stock is to be maintained.

RELATIVE MERITS OF THE PRECEDING PRACTICES.

In the preliminary discussion of seed-potato improvement in this bulletin it is intimated that the chance of securing a superior strain of a commercial variety of potato through selective processes is not as great as earlier writers on this subject have claimed. A careful consideration of all the experimental evidence thus far presented would seem to justify the conclusion that the tuber-unit method of seed-potato improvement does not afford as satisfactory a starting point for selection work as the hill-selection method. The evidence at hand would also seem to indicate that neither of these practices is to be commended to the average grower of seed potatoes, as both methods involve an expenditure of a greater amount of time and effort in properly observing the details necessary to their successful application than can reasonably be expected of such a grower. The tuber-unit and hill-selection methods can only be recommended to those growers who have ample time or means to undertake these studies and to those experiment-station investigators who have the facilities necessary for carrying on such work.

The "mass-selection" and the "field-roguing" methods are more nearly adapted to the average grower, as neither method involves the growing and keeping separate of a large number of individual selections. Both are so simple of execution that any person of ordinary intelligence can practice them.

Strain testing involves a somewhat more elaborate plan of operation, in that it requires the purchasing and growing of several strains of a given variety under as nearly identical conditions as it is possible to supply. This method of seed-potato improvement may be best undertaken by the type of men suggested for the conduct of the tuber-unit and hill-selection systems. The average grower should avail himself of the findings of those engaging in strain testing and purchase his seed from those growers having the most desirable seed stock, as demonstrated by such tests.

REQUIREMENTS FOR SUCCESS.

The only requirements for the successful practice of the first two methods of seed selection are a reasonable degree of painstaking effort on the part of the grower, some 12-inch garden labels, a small pair of balances, a sufficient number of suitable small sacks, and a safe place in which to store the selected tubers until required for the next season's planting. In addition to this, the grower should have a breeding plat in which each season's selections can be developed up to the point of field-planting stock. This selection or seed plat should be located at as great a distance from the commercial potato field as possible in order to secure the greatest degree of isolation that is feasible. Heretofore the problem of isolation has not received due consideration. This was largely owing to the fact that the seriousness of such diseases as mosaic, leaf-roll, curly-dwarf, streak, and spindle-tuber has only recently come to be recognized. The fact that all of these diseases are readily transmitted from diseased to healthy plants through the instrumentality of plant lice, or aphids, and the further fact that as yet there is no reliable information as to the distance insects may transport these diseases suggest as complete isolation of the seed plat as possible. The latest suggestion in regard to the production of seed potatoes under isolation is that each variety be grown separately, as it has been found that stock of certain varieties supposed to be free from mosaic have served as disease carriers to more susceptible varieties. For example, it is not desirable to grow the Irish Cobbler adjacent to the Green Mountain intended for certification, as the former may carry the mosaic virus without expressing it. The danger from contamination of the healthy Green Mountain strain by the Irish Cobbler is considered sufficiently great by some seed-certification agencies to cause them to refuse to consider stock thus grown as eligible for certification. The ultimate success of the seed plat in so far as the elimination of tuber-borne diseases is concerned rests largely upon the ability of the grower to recognize diseased plants and the promptness with which they are removed from the seed plat and destroyed. Frequent and thorough inspections of the seed plat are necessary to insure the largest possible reduction of diseased plants and to reduce the transmission of disease from diseased to healthy plants.

SEED TREATMENT.

It is impossible to produce high-grade seed potatoes if the seed planted is infected with disease organisms capable of infecting the crop. The disinfection of the seed potatoes is therefore necessary if the best results are to follow. The two diseases for which seed potatoes are ordinarily treated are common scab and black scurf, or Rhizoctonia. The two disinfecting agents recommended for such treatment are formalin and corrosive sublimate (mercuric chlorid, or bichlorid of mercury). Formalin is as effective against the common scab as corrosive sublimate, but it does not give as good results in the destruction of the black-scurf fungus. When the latter is present on the tubers corrosive sublimate should be used. The formulas recommended for these two disinfectants are as follows:

(1) Formalin, 1 pint. Water, 30 gallons.	(2) Corrosive sublimate, 4 ounces. Water, 30 gallons.

If the formalin treatment is selected the seed potatoes should be soaked in this solution from one-half to 1½ hours. Recent experiments by Dr. I. E. Melhus, of the Iowa Experiment Station, indicate that an immersion of the seed potatoes for 2 minutes in a formalin solution of twice the stength mentioned heated to a temperature of 122° F. and covered for an hour after their removal from the hot liquid is just as effective as the longer treatment in the cold solution.

When the corrosive-sublimate solution is used, the length of the immersion should be governed by the condition of the tubers and their freedom from, or the severity of, the black-scurf infection. If the tubers are dormant and they are more or less infected with the sclerotia of the black scurf the treatment may be prolonged to 1½ or 2 hours. If they have started to germinate and are reasonably free from black scurf the period may be shortened to a half hour or less.

The treated tubers should on no account be allowed to come in contact with such receptacles as old sacks and barrels in which diseased seed has been handled, as they are almost certain sources of reinfection.

PREPARATION AND FERTILIZATION OF THE SOIL.

Strong, vigorous plants can not be produced on land that has been poorly prepared or that is deficient in available plant food. Seed potatoes should be grown on land that has been deeply plowed and thoroughly prepared to receive the seed. It should be well supplied with organic matter and available plant food. A clover or alfalfa sod furnishes the organic matter and considerable of the plant food. Barnyard manures or commercial fertilizers, or both, will supply the additional plant food necessary to produce a good crop

CAREFUL CULTURAL PRACTICES.

The vigor of the seed stock produced is to a large extent dependent on the care given to the growing crop. Uniformity in the size of the tubers is to a large extent governed by the rate of planting. Closer planting should be practiced in the growing of seed than of table stock. Some growers in Aroostook County, Me., space their rows from 32 to 36 inches apart and the plants in the row 8 to 12 inches. The crop should be cultivated as frequently as may be necessary to provide the most suitable growing conditions.

Every effort should be made to protect the plants from injury by insect or fungous pests. Leaf-eating insects can be effectively controlled if the plants are thoroughly sprayed with arsenical poisons; sucking insects with contact solutions, such as kerosene emulsion and nicotine; and fungous diseases, such as the early and late blights, with Bordeaux mixture. In every operation it should be remembered that whatever contributes to the health of the plant increases the vigor of the seed stock produced.

ELIMINATION OF VARIETAL MIXTURES AND DISEASED OR WEAK PLANTS.

The vegetable-seed growers employ the term "roguing" to denote the process of removing all mixtures or off-type plants from the seed plat. As this term, when understood, is a brief and yet sufficiently descriptive way of indicating the process of eliminating all undesirable plants or "rogues," it is proposed to use it in this connection.

It is an easy matter to rogue a seed-improvement or selection plat during the growing season. Varietal mixtures are more easily detected when the plants are in bloom. Weak plants are usually apparent in the early stages of their growth, as are also certain types of diseases, such as mosaic and black-leg, although both may appear later. Plants infected with Rhizoctonia and Fusarium are usually not apparent until the latter part of the growing season. It is evident from these statements that in order to rogue the seed plat thoroughly it is necessary to make two or three examinations of the field or plat during the growing season. Further roguing should be done when the crop is harvested by discarding the progeny of all low-producing plants. (Fig. 5, *A*.)

MONETARY VALUE OF GOOD SEED POTATOES.

The producer of high-grade seed potatoes is justly entitled to a fair monetary return for the special efforts he has made to produce quality seed stock. This is especially true where a seed plat is maintained year after year and the crop has been officially inspected and passed by a duly authorized seed-certification inspection officer. Just what increase in price over ordinary stock one is entitled to receive for such efforts and for the inspection fees involved is not an easy matter to determine. It is believed that a premium of 50 cents per bushel over the market price of table stock of the same variety is ordinarily sufficient to amply repay the grower. Opinions, however, will differ upon this point. At the present time the price of certified seed stock varies all the way from $1 to $3.50 per hundredweight—60 cents to $2.10 per bushel.

IMPORTANCE OF TUBER SHAPE.

Reasonable trueness of the tubers to varietal type is generally demanded by the purchaser of certified seed. And most writers who have dealt with the subject of good seed have always placed strong emphasis upon the importance of its being true to type. Rather recently, however, some scientific as well as practical growers have been disposed to regard tuber shape as being of less importance than has been previously supposed. They have come to regard tubers that have departed from the type as a result of unfavorable environmental conditions as being satisfactory for seed purposes.

As a result of a long-continued preachment of the undesirability of slightly off-type tubers for seed purposes many cars of otherwise high-grade seed stock have been annually rejected by the southern truck grower. This is particularly true in the case of conspicuously flattened and somewhat elongated tubers of the Irish Cobbler variety. The Irish Cobbler grower in the South has come to demand roundish tubers and is suspicious of the purity of seed stock containing flattened and somewhat elongated tubers and generally protests their acceptance as strictly first-class seed stock. In fact, he is inclined to regard the off-type tubers as Green Mountain. The only obvious way of correcting these firmly rooted convictions is to demonstrate experimentally that off-type tubers resulting from unfavorable soil, cultural, or climatic conditions are no more likely to produce off-type progeny than are normal-shaped ones. This statement, however, does not apply to off-type tubers resulting from disease; such tubers should not be planted. The spindle-tuber recently recognized by pathologists as a communicable disease is very similar in its method of transmission to that of leaf-roll and the mosaic disease. Figure 6, *A*, represents a fairly good example of spindle tubers. It is important, therefore, in the purchase of somewhat off-type seed potatoes to know whether the change in shape is really due to unfavorable environmental factors and not to disease.

CAREFUL HARVESTING AND STORAGE OF THE CROP.

The average grower does not fully appreciate the importance of using every means to prevent the mechanical injury of the tubers during the process of harvesting and storing. If the crop is grown on land containing a plenteous admixture of small stones the tubers are almost certain to be more severely injured in harvesting than when grown in a sandy loam soil. Hand digging is not always feasible, but it is believed that where small stones abound in the soil it will be desirable to harvest the home seed plat by hand. Much injury will be avoided if the seed stock designed for planting the field plat of the ensuing year is picked directly into crates in which it is allowed to remain throughout the storage period.

The storage conditions necessary to insure vigorous seed at planting time are more easily provided in the North than in the South. In the former region a well-constructed cellar, pit, or cave serves reasonably well. The main thing is to keep the room temperature sufficiently low to retard germination. The ideal seed tuber is one which has not wasted any of its stored-up energy by excessive loss through sprouting. (Fig. 7.) It should be firm, with the first sprouts just showing. Such tubers can be depended upon, if suitable conditions prevail, to start quickly when planted and to make a vigorous growth.

The general practice among southern growers of securing seed from the North involves in the absence of suitable storage conditions one of two things: Either getting the seed potatoes late in the fall and holding them over in dugouts, pits, or cellars, with consequent sprouting before planting, or the risk of having the seed chilled, frozen, or overheated while in transit in midwinter. In the writer's opinion the greatest need of the large southern truck grower at present is that of suitable storage facilities for handling fall shipments of seed potatoes. As a purely economic proposition the proposed change ought to commend itself. In probably nine cases out of ten the difference in first cost of these potatoes as between fall and midwinter shipments would more than offset the extra cost of storage, while the added security from danger of chilling or freezing the shipment would still further compensate the grower.

For further particulars on storage, consult Farmers' Bulletin 847, entitled "Potato Storage and Storage Houses."

LARGE COMPARED WITH SMALL SEED TUBERS.

In seasons of short production and consequent high prices for table stock, the question is frequently raised as to the advisability of using the small unsalable tubers for seed. The answer to this question is that it is always unsafe to use small tubers for seed purposes unless one is absolutely certain that they have been produced by healthy, vigorous, and productive plants. As a result of some experimental study of this question by Ballou and Gourley[4] it was found that the use of large tubers gave—

(*a*) A very heavy, perhaps almost total, percentage of the high-producing strains.

(*b*) A heavy percentage of the average or moderate-yielding strains.

(*c*) A very small percentage of the inferior or low-producing strains.

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[4] Ballou, F. H., and Gourley, J. H. I. The status of the potato growing industry in Ohio. II. Seasonal notes on potatoes. Ohio Agr. Exp. Sta. Bul. 218, p. 587. 1910.

The use of small potatoes gives—

(*a*) A very insignificant percentage of the superior or high-yielding strains.
(*b*) A small percentage of the average or moderate-yielding strains.
(*c*) A very heavy, almost total, percentage of the low-yielding or inferior strains.

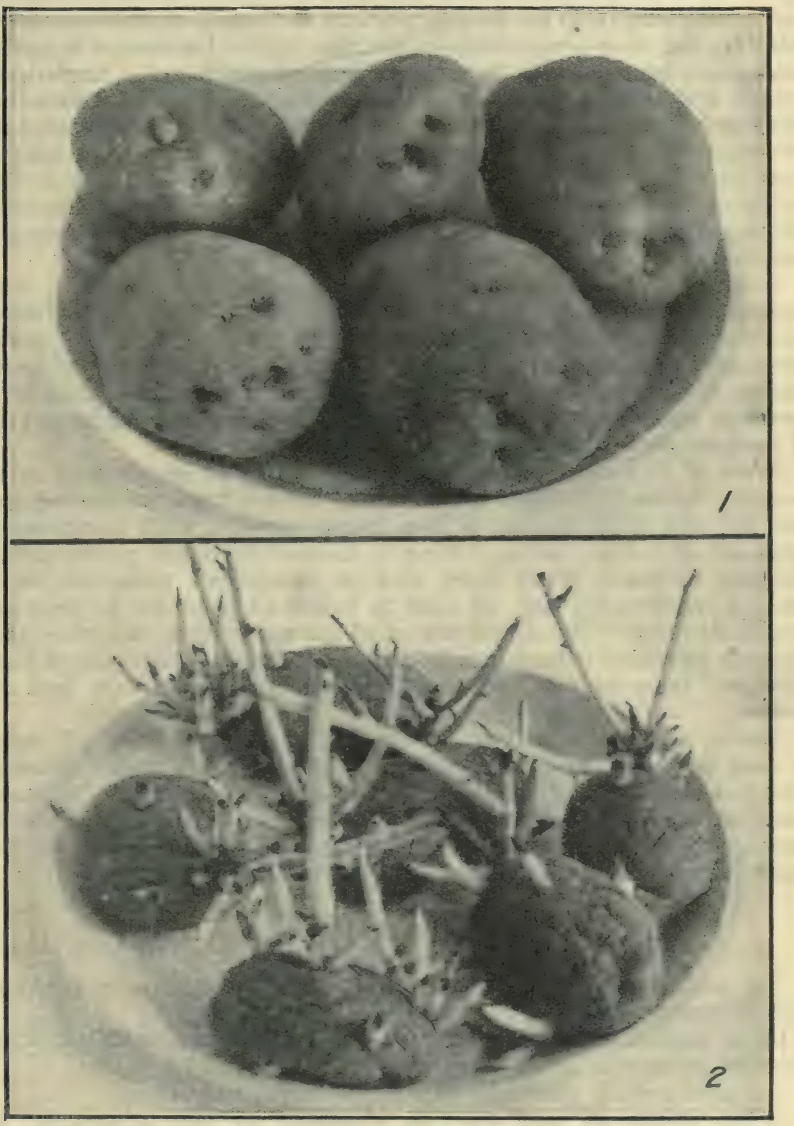

FIG. 7.—Potatoes for seed purposes, showing different stages of germination: 1, Desirable; 2, undesirable.

The use of small seed potatoes is only permissible when they are known to have been produced by strong, healthy, and productive plants. It is never advisable to use small tubers from the general mass produced from unselected stock.

WHOLE COMPARED WITH CUT SEED.[5]

Considerable attention has been paid to the subject of whole versus cut seed at various times by the State agricultural experiment stations. The data accumulated in these investigations are for the most part conflicting in so far as they pertain to the use of whole seed. In general, the data show that within reasonable limits the larger the seed piece planted the larger is the crop produced. English and Scotch potato growers almost without exception plant whole tubers. The seed used usually runs from 1¼ to 2¼ inches in diameter, being screened out of a crop which as a rule has been grown especially for seed purposes. They are harvested before they are mature, and but a relatively small proportion of the crop exceeds the size mentioned. These growers believe that an earlier and more vigorous growth is secured from immature tubers.

Some of the reasons why European growers have adopted whole seed and are succeeding in producing profitable crops are as follows: (1) They are assured of an almost perfect stand; (2) there is greater freedom from disease; (3) the almost universal practice of germinating their seed before planting insures a minimum number of sprouts; and (4) the greater fertility of their land makes large yields of medium-sized tubers possible.

Some of the reasons for failure in the use of whole seed in this country follow: (1) The use of small tubers from unselected stock and (2) the development of too many sprouts, with a consequent large set of tubers, which, owing to lack of thorough preparation of the soil, to scant plant food, and to insufficient moisture, do not reach a marketable size, at least in sufficient numbers to produce a profitable crop. The development of too many sprouts comes about through planting tubers in a dormant condition, which under favorable soil temperature and moisture starts almost every bud into growth.

Scotch and Irish potato growers plant not less than 37 bushels of seed per acre, and frequently this quantity is greatly exceeded. The American grower, on the other hand, plants from 7 to 16 bushels per acre, with an average of 9 to 11 bushels. It is believed that the average potato production of the United States would be very materially increased if a larger quantity of seed were used.

SUMMARY.

The production of high-grade seed potatoes should be regarded as a special business.

Good seed is a determining factor in the production of maximum crops of potatoes.

Certified seed is generally superior to noncertified seed.

Good strains of seed may be obtained by the tuber-unit, hill-selection, mass-selection, field-roguing, or strain-test methods through the process of elimination.

Like produces like. If tubers from unproductive, weak, or diseased plants are planted, a poor harvest will be reaped. Use seed from productive plants.

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[5] Stuart, W., and others. Size of potato sets: Comparisons of whole and cut seed. U. S. Dept. Agr. Bul. 1248, 43 pp., illus. 1924.

Purity of seed stock is an essential quality of good seed. Serious losses are sustained by the grower through mixtures.

Good seed can not be produced unless the growing plants are well cared for and the strain of seed planted was a good one.

A more liberal use of good seed would materially increase the average production per acre.

All seed should be disinfected before planting.

Experimental evidence does not indicate that whole seed is superior to cut seed, at least so far as it relates to the United States.

Good storage facilities are essential to insure sound, firm seed at planting time.

ORGANIZATION OF THE UNITED STATES DEPARTMENT OF AGRICULTURE.

April 28, 1925.

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U. S. DEPARTMENT OF AGRICULTURE
FARMERS' BULLETIN No. 1333

PRUNING CITRUS TREES IN THE SOUTHWEST

PROGRESSIVE GROWERS of both citrus and deciduous tree fruits are coming to realize more and more that pruning is one of the most important operations to which they have to give attention in connection with the maintenance of their orchards; that, wisely performed, it may be made to contribute materially to the success of their enterprise; but if done injudiciously it may largely defeat not only its own ends, but the ends for which all other operations in the orchard are performed.

It is only the grower who is able the most accurately to interpret in terms of pruning the appearance and behavior of his trees who can judge best as to the type and extent of pruning which will be most beneficial in the case of a particular tree.

Constructive pruning consists of much more than the indiscriminate removal of limbs which seem to be in the way. Pruning is a physiological operation which may promote or interfere with the normal and efficient functioning of the different parts of the tree, including its root system. The grower should remember that the raw food material taken up by the roots is elaborated in the foliage, and that any pruning which greatly disturbs the relationship of the leaf area to the food supply and the requirements of other parts of the tree is likely to result adversely.

The information presented in this bulletin is based largely on careful observations made of citrus trees in California in connection with the investigations in fruit improvement through bud selection. It has been brought out in these studies that the details of pruning of individual trees are very largely influenced by the character of the buds used in propagation. These studies have established certain principles which may be enumerated as follows:

Little pruning is necessary in the case of trees grown from buds taken from the fruit wood of superior parent trees.

Severe pruning of normal citrus trees is unnecessary and injurious.

Early fruit-bearing growth on young trees should not be cut off.

Pruning should be guided by the behavior of pruned as compared with unpruned trees, as shown by their performance records.

Washington, D. C. Issued June, 1923.

PRUNING CITRUS TREES IN THE SOUTHWEST.

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INTRODUCTION.

THE CITRUS GROWERS of California and Arizona became keenly interested in the work of pruning following the freezes of the winter of 1912–13. Previous to that time there had been wide differences of opinion with regard to the desirability of pruning healthy full-bearing trees, and the methods practiced by those who believed pruning to be a necessary part of citrus culture varied greatly in degree, time of operation, and other important factors. This was largely due to the absence of definite knowledge of the effects on crop production resulting from any specific system of pruning.

Frost injury to citrus trees during the 1912–13 freezes stimulated a widespread interest in pruning during subsequent seasons, and many crews of experienced pruners were organized, representing in their methods of work wide variations from previous practices. In order to determine the effect of these practices upon fruit production, the writer and his associates carried on a series of comparative pruning studies with full-bearing orange, lemon, and grapefruit trees located in a large commercial orchard in a typical citrus district of southern California. The results of these studies of the behavior of pruned and unpruned full-bearing citrus trees show that under the conditions in the orchard where this investigation was conducted, heavy pruning was detrimental to the yield and commercial value of the crops borne by normal full-bearing trees of orange, lemon, and grapefruit varieties about in proportion to the severity of pruning. Not only were the yields reduced by pruning, but there was no apparent improvement in the commercial sizes or grades of the fruit borne by severely pruned as compared with those from unpruned trees. The results of this investigation demonstrated the necessity for definite information based on individual tree-performance records as to the behavior of pruned and unpruned trees under different conditions as a basis for establishing safe and efficient methods of pruning. This bulletin briefly discusses some of the underlying principles of pruning and training citrus trees which have developed as a result of these experimental studies and from observations of the results of commercial pruning practices.

OBJECTS OF PRUNING.

The necessity for pruning citrus trees begins in the nursery and continues during their entire lifetime. The objects of pruning include (1) heading the young nursery trees; (2) training the main limbs in order to form the strongest possible framework; (3) removal of objectionable branches, such as crossed limbs, suckers, and injured or decadent growth; (4) thinning the fruit-bearing wood to admit light and stimulate the rate of growth of the fruits or to influence their size; (5) control of the arrangement and distribution of the vegetative growth in order to have well-balanced tops and accessible fruit; (6) treatment of limbs or trees attacked by fungous diseases or insect enemies; and (7) renewal of old and decadent trees.

METHODS OF PRUNING.

From time to time various pruners have introduced rather definite methods of pruning in California and Arizona citrus orchards which differed mainly in the quantity and kind of growth removed, in the shape of tree tops left after pruning, and in the plan of arrangement of the framework or other similar characteristics. For one reason or another most of the radical systems have been largely abandoned in commercial orchard pruning. The good points, if any, of each system as brought out by experience have been preserved and the others discarded. The method which has evolved as a result of experience and observation of the behavior of trees pruned according to individual practices may be termed the California method. A brief description of this method follows.

HEADING YOUNG TREES.

The principles of heading of young orange, lemon, and grapefruit trees are practically the same.

Heading the young citrus trees is usually done in the nursery, and usually 28 to 30 inches above the bud union. Low heading was formerly popular because it was thought that this arrangement would result in developing low tree tops with easily accessible fruit. As the fruits borne by the lower branches of such trees are frequently injured by contact with the ground or with implements of culture, the low-heading practice has been generally abandoned. Following the extremely low-heading method, extremely high heading was practiced by some propagators. This practice also fell into disrepute on account of certain disadvantages which became evident with experience, including greater cost of picking and increased expense of fumigation and other tree treatments. Both of those extremes have been largely abandoned, and during the past few years young trees have been generally headed so as to avoid the difficulties which result from trees having extremely low or very high heads.

Heading is accomplished by cutting off the tops of young trees at the height at which it is desired to form the head, as shown in Figure 1. It is advisable to use a measuring stick in order to make all of the cuts at a uniform height above the ground.

ARRANGEMENT OF THE MAIN BRANCHES.

After heading, or topping as it is frequently called, numerous branches develop on the young tree trunks back of the cuts. Formerly it was the custom to cut or break off all of these growths except three to five immediately back of each cut. This plan resulted in developing a head consisting of several main branches arising at or very near the same point. This form of head has been found to be somewhat undesirable on account of the tendency of the main branches to split off under the strain of heavy crops of fruit. A better arrangement of the branches intended for the main limbs is to space them several inches apart, so that they will arise at different points along the tree trunks. From three to five branches should be left on each tree for this purpose, spaced spirally around the trunk in order to develop into a well-balanced and strong framework for the future tree tops, as shown in Figure 2. All growth other than that intended for the framework limbs should be carefully removed during the first season after heading, as shown in Figure 3.

One style of forming the framework of trees is developed in the following manner: As soon as the young main limbs make a period of growth they are cut or pinched back. Following this pruning additional branches will develop back of the cuts on each limb. These growths are usually thinned to two or three located on the outside of the limbs, as shown in Figure 4. The second season each of the growths of the preceding season should be cut back, and the resulting branches thinned as before. In this way a bowl-shaped framework will be developed, which under certain circumstances is desired by many citrus growers.

Another framework arrangement preferred by some citrus growers has several points of apparent advantage. This arrangement is secured by allowing the original main limbs to grow uninterruptedly, taking care to thin out interfering growth. By following this plan the final framework will consist of from three to five upright growing limbs. Such trees are usually referred to as having a vase shape in contrast to those with the more spreading and open bowl shape. A 6-year-old Lisbon lemon trained to the vase shape is shown in Figure 5, and the interior framework of this same tree is shown in Figure 6. Among the advantages claimed for the vase-shaped trees are greater strength of framework, better protection to the

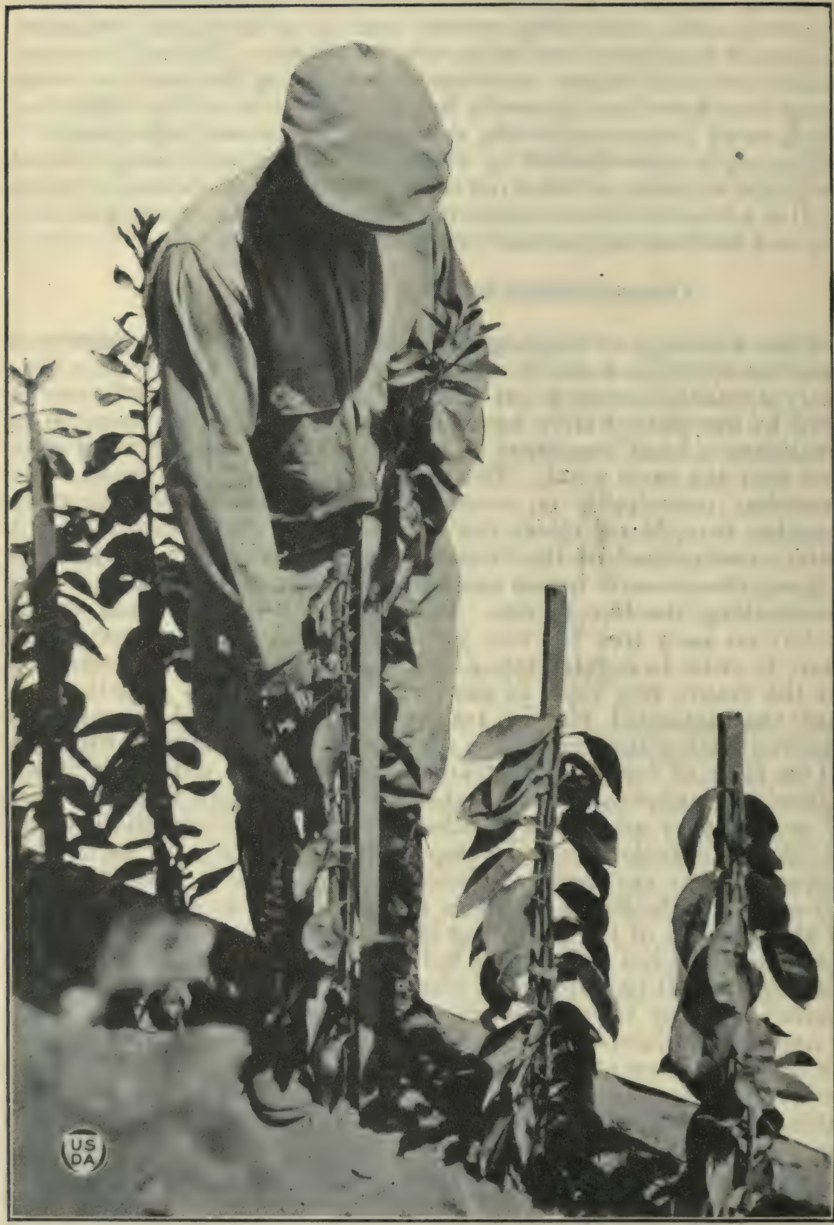

FIG. 1.—Topping young citrus trees in the nursery for the purpose of developing the heads. A measuring stick is used in this work, so as to make the cuts at a uniform height from the ground. The cuts are usually made with short-handled shears.

fruits from sunburn or other exposure, and longer life. It is rather significant that the trees in several of the oldest and best citrus orchards in California have been trained to the vase or upright shape. An apparent disadvantage of this method lies in the greater expense of picking the fruit from the taller vase-shaped trees as compared with the cost of harvesting the lower growing bowl-shaped trees. Another possible disadvantage of the vase-shaped trees, as contrasted with the lower growing bowl-shaped trees, lies in the increased cost of fumigating, spraying, pruning, and other tree treatments.

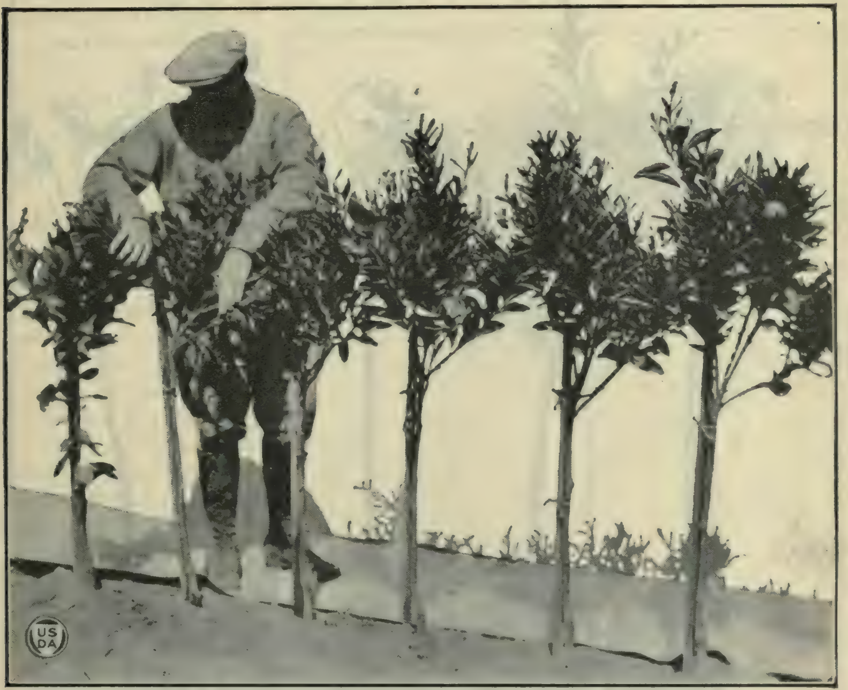

FIG. 2.—Young nursery trees after pruning following the second season of growth. A more desirable practice would have been to space the branches farther apart.

Decision as to the arrangement of the framework of the trees will depend largely upon local conditions, including variety, probable exposure to wind and sunburn damage, cost of labor in picking, expense of disease and pest control, and other factors of tree care. With the inherently fruitful strains of trees now commonly grown in the Southwest the vase-shaped system of framework arrangement is usually considered superior to the bowl shape.

CARE OF THE EARLY FRUIT-BEARING GROWTH.

Up to seven or eight years ago there was a general tendency to prune off the early fruit-bearing growth from young citrus trees. The theory on which this practice was based was that early production of fruit was detrimental to the development of the young trees. Ten years ago a considerable acreage of citrus trees grown from carefully selected buds secured from heavy-bearing parent trees producing uniformly good fruits was planted in several locations in different citrus districts of southern California. In order to obtain an early measure of the productiveness of these progeny trees and definite evidence as to the strain characteristics of the fruits borne by them, none of the early fruit wood was removed. The only pruning practiced with these trees was to control the arrangement of framework limbs. The trees began to bear commercial quantities of particularly uniform and desirable fruits during the second year after planting in the orchards. A typical example of one of these trees is shown in Figure 7. Subsequent tree-performance records and observations of these and comparable trees pruned in the ordinary way have shown that early fruiting of the unpruned trees has had no apparent detrimental influence on the growth or behavior of the trees. On the contrary, the unpruned young trees

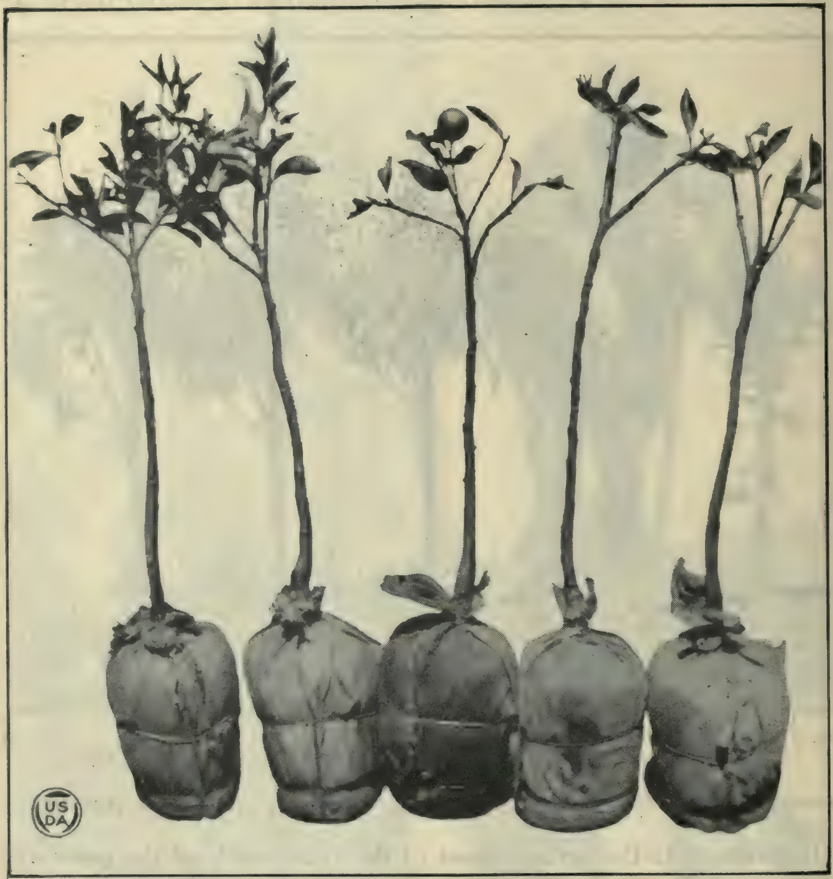

FIG. 3.—Young citrus trees similar to those shown in Figure 2 after balling and ready for planting, showing the arrangement of the framework branches, which should have been spaced farther apart, and the method of pruning preliminary to transplanting.

made a better growth and developed into better trees from all standpoints than those where the early fruit wood was removed. This conclusion has been repeatedly confirmed during recent years in many large commercial citrus plantings. These facts are of great importance for a number of reasons, including the saving of the cost of pruning, the production of a valuable early crop, and the better growth conditions of the unpruned or lightly pruned as compared with the more severely pruned young trees. Experience of recent years both in an experimental as well as a commercial way shows that the early fruit-bearing growth of young citrus trees should not be pruned off.

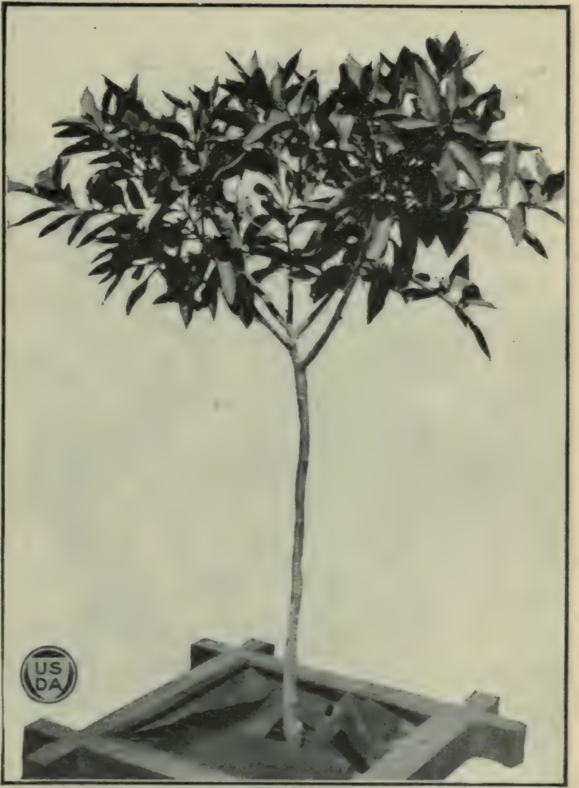

FIG. 4.—Young citrus tree six months after planting, showing the arrangement of branches, form of head, and habit of growth.

With trees grown from carefully selected buds secured from superior parent trees there is likely to be very little objectionable growth to be removed. With ordinary trees, particularly those producing considerable sucker growth, it is probable that rather frequent thinning and removal of such growth will be necessary. A 3-year-old Eureka lemon tree propagated from a parent tree of one of the vegetative strains is shown in Figure 8. Comparing this tree with the one shown in Figure 7 it is seen to be producing a dense growth of nonbearing branches, which require pruning and thinning, rather than the fruiting wood which is to be desired.

PRUNING FULL-BEARING ORANGE AND GRAPEFRUIT TREES.

The term "full-bearing" is here used to define citrus trees during that period following early fruiting and before production is interfered with by reason of old age, decadence, and related causes. The methods of pruning full-bearing orange and grapefruit trees are so nearly alike that their care in this respect may be considered under one head. The pruning of full-bearing lemon trees differs in some particulars from that of orange and grapefruit trees and will be described separately.

In the experimental studies of the behavior of unpruned healthy full-bearing orange and grapefruit trees as compared with those pruned with different degrees of severity, as shown by the quantity of growth removed and by somewhat different commercial pruning systems, it was found that the unpruned trees consistently produced more fruit during the 5-year period of investigation. A typical unpruned Washington Navel orange tree in this investigation is shown in Figure 9 and a severely pruned tree in Figure 10.

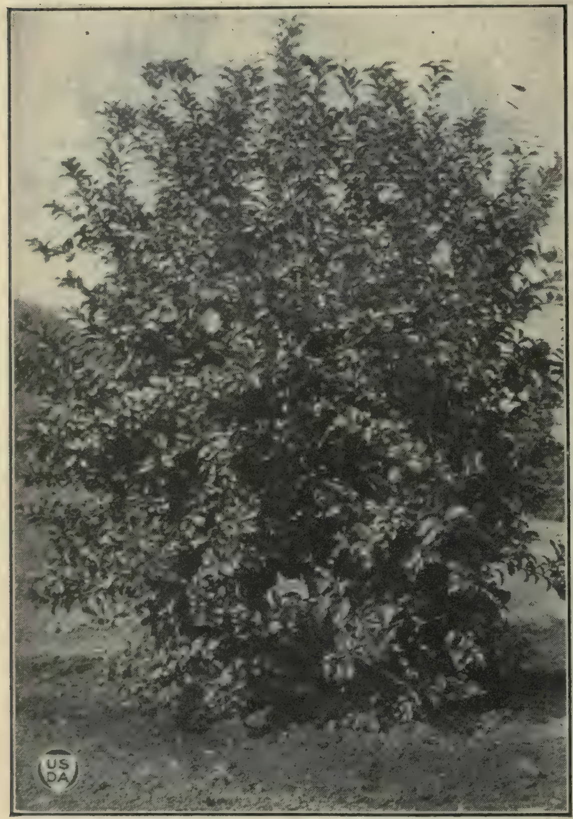
FIG. 5.—A 6-year-old Lisbon lemon tree trained to the vase shape. The interior framework of this tree is shown in Figure 6.

The unpruned trees produced larger crops, and the fruits were practically the same in size and grade as those borne by the pruned trees.

These results were contrary to theories commonly accepted at the time this study was carried on. Subsequent experimental study and extensive observations of results of commercial pruning have confirmed the conclusions reached as a result of these investigations.

After considering all available experimental evidence and commercial results, it can be said that little pruning should be done in healthy and normal full-bearing orange and grapefruit trees. It seems advisable to remove dead or decadent growth which might bruise, scratch, or otherwise injure the fruits. Suckers or other objectionable branches should be removed. With inherently productive trees there are very few such growths.

PRUNING FULL-BEARING LEMON TREES.

On account of their more abundant and vigorous vegetative growth it seems probable that full-bearing lemon trees need more regular pruning than orange and grapefruit trees. From the fact of their lower resistance to frost the season of pruning is probably more vital in the case of lemon than of orange and grapefruit trees.

Cutting back the limbs of bowl-shaped lemon trees or thinning the larger growths of vase-shaped trees should be done during late winter or spring after danger of injuries from low temperatures has passed. This pruning will usually be followed by the development of numerous branches, especially in vegetative strains, which should be thinned or cut back during the summer months, preferably not later than the first of August. In this way any growths stimulated by summer pruning will reach sufficient maturity, or "harden up" as this condition is commonly called, before danger of frost injury.

Heavy pruning of healthy normal lemon trees has been found to be as injurious as the severe pruning of orange and grapefruit trees. Sometimes this practice seems advisable in order to accelerate the rate of growth of the fruits so as to secure merchantable sizes for particular market seasons or for other reasons. The season of fruiting of lemons can be appreciably influenced by pruning through hastening the rate of growth, but the most effective means for securing this result is by withholding or applying irrigation water at certain periods in order to hold back or stimulate growth and blossoming.

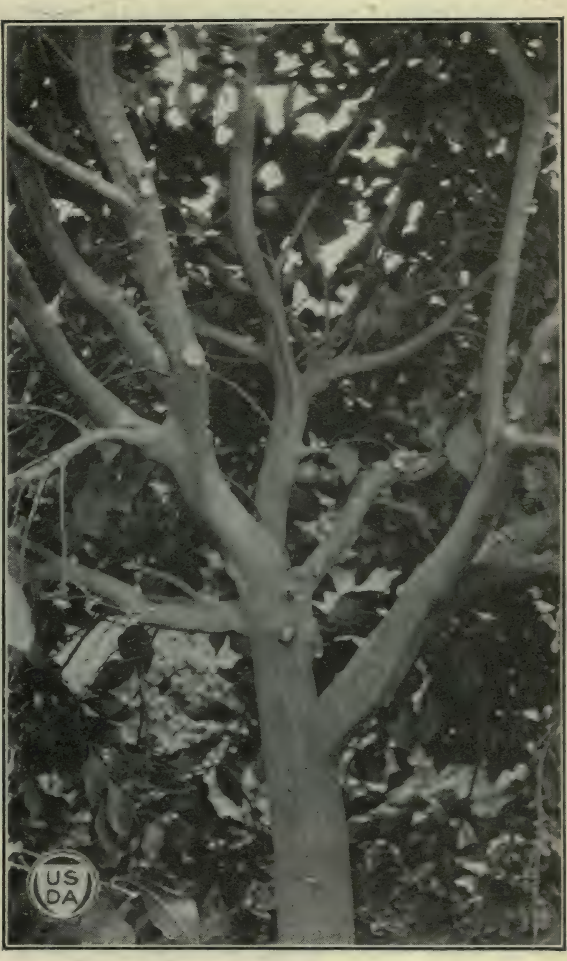

FIG. 6.—The interior framework arrangement of the Lisbon lemon tree shown in Figure 5. Some of the branches of this tree have been cut out in order to photograph the framework.

All available information on this subject shows that the pruning of normal full-bearing lemon trees should ordinarily be confined to control of the framework arrangement of the trees, removal of dead or decadent branches which might injure the lemons through scratches or bruises, and special treatment of injured or decadent trees, as discussed under separate headings. A typical unpruned lemon tree is shown in Figure 11, a lightly pruned tree in Figure 12, and a severely pruned tree in Figure 13. Subsequent production of pruned trees for a 5-year period was cut down about in proportion to the severity of pruning.

RENEWAL OF OLD NEGLECTED AND DECADENT TREES.

A study by the writer during 1913 of navel-orange trees in the vicinity of Bahia, Brazil, where orchards of this type have been maintained for about a century, revealed the fact that the older trees in these orchards had been renewed periodically by cutting off most or all of the tops and encouraging the growth of new framework and fruit-bearing branches. Very little or no pruning other than occasionally cutting out dead or other objectionable branches was practiced between the periods of tree renewal.

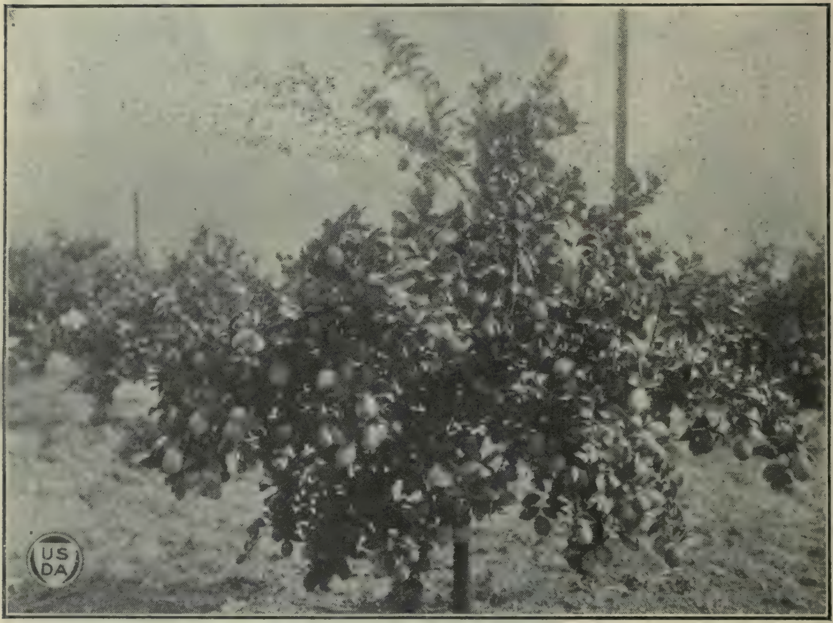

FIG. 7.—Productive strain of Eureka lemon tree 2 years old, showing little or no need for pruning in an inherently fruitful citrus tree.

As a rule, the trees in the old orchards had been renewed at intervals of about 25 years. Growth of the renewed trees, cut back in about the same degree as for top-working, proved to be vigorous, healthy, and fruitful. In several of the oldest orchards evidence was found that some of the trees had been renewed in this way at least three times with apparent success.

A study of results of tree renewal with old and neglected citrus trees in California, similar to that practiced in orchards at Bahia, has shown that it is frequently successful if environmental conditions are favorable. Cutting back should be done in the late winter or early spring. Tops of trees to be renewed are usually cut back very much in the same way as for top-working, except healthy horizontal and drooping branches near the heads of trees, which are usually allowed to remain undisturbed. Figure 14 shows decadent Washington Navel orange trees cut back very severely for the purpose of tree renewal. New growth following severe cutting back is trained in a manner similar to that of young trees, in order to develop strong and well-balanced tree tops. Trunks and portions of limbs left after the tops have been removed are protected by a coating of whitewash[1] applied immediately after the pruning.

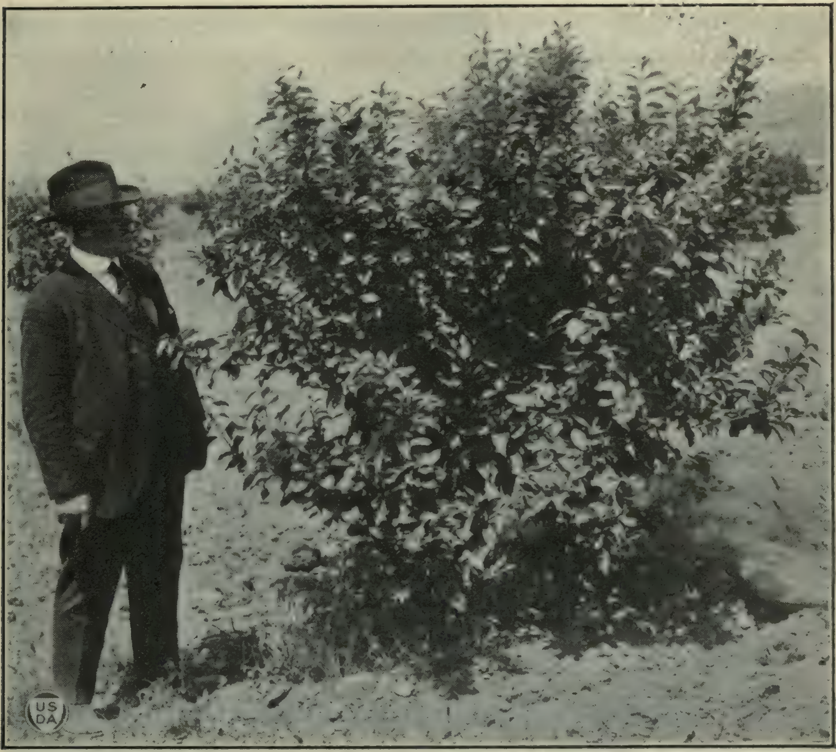

FIG. 8.—Eureka lemon tree 3 years old grown from a bud secured from an unproductive parent tree. Such trees require frequent pruning in order to thin the vegetative growth and cut back the long weak limbs. Note the entire absence of fruit on this tree in comparison with the productive tree shown in Figure 7.

The advisability of attempting to renew decadent or old neglected trees which have become unproductive for various reasons must be determined through a consideration of local tree and environmental conditions. If trees are very badly diseased or injured by insect attacks, or if they show signs of decadence by reason of mottle-leaf, chlorosis, or related troubles, it is probable that tree renewal will be of little value in most instances. Most leading growers now prefer to remove badly diseased trees and replace them with healthy young trees.

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[1] The formula commonly known as California tree whitewash is as follows: 30 pounds of quicklime, 4 pounds of tallow, 5 pounds of salt. Dissolve the salt in a little water, melt the tallow, and mix it with the salt solution. Slake the lime and add the salt and tallow mixture. Dilute with enough water to make the mixture flow well. It can be applied by hand with a brush, but when a large number of trees are to be treated it is most economically applied through a spray nozzle by means of a power sprayer.

In the case of older trees which have become unproductive by reason of neglect, poor cultural treatments, or other environmental conditions and where the bark of many of the limbs has become hidebound, tree renewal by severe pruning has been used with good results in many instances. Where the orchard to be renewed contains off-type trees of undesirable strains these trees should be top-worked. This plan provides for improving the strain characteristics of the trees as well as for securing the benefits of tree renewal. If bark conditions on the trees are unsatisfactory for top-working, sprouts should be grown after cutting back the framework limbs, into which selected buds can be inserted. Directions for top-working citrus trees can be found in Farmers' Bulletin 794, Citrus-Fruit Improvement: How to Secure and Use Tree-Performance Records.

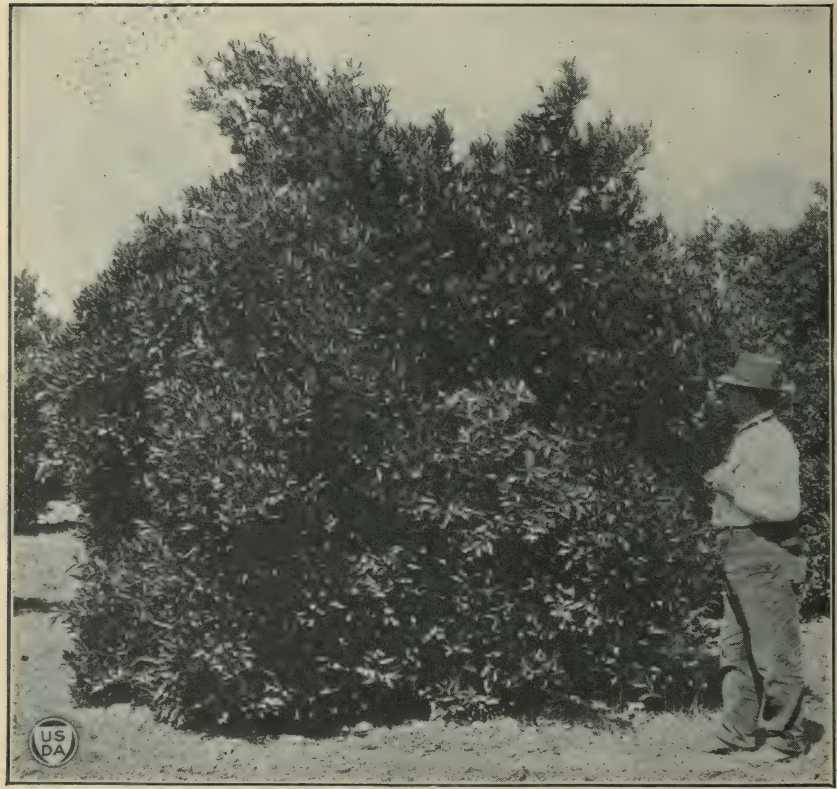

FIG. 9.—Unpruned Washington Navel orange tree 11 years old.

PRUNING FROST-INJURED TREES.

Low temperatures have been responsible for occasional injuries in varying degrees to some of the growth on citrus trees in many districts in the Southwest. Usually only the younger and more tender growth is killed by low temperatures. As a rule, the more severe frosts occur during December and January. Under these conditions the injured growth should be left untouched until after new growth has started during the subsequent spring months. It is then possible to distinguish clearly the injured growth. It is a good plan to cut off dead and badly injured branches an inch or more back of the area of visible injury, in order to make sure of removing all dead or injured growth.

In the case of split bark on trunks or larger limbs the injured areas may be treated and their recovery hastened by carefully wrapping the wounds with twine, strips of cloth, or other similar material so as to bind the loose bark to the wood. Twine or strips of cloth should be wound spirally around the trunk or limb, leaving the greater portion of the bark uncovered and allowing free access of air but holding the loose bark firmly against the wood. This work must be done promptly after injury. If delayed for some time the wrapping will not be beneficial. Such treatments should be examined occasionally in order to detect possible molding or other difficulties. After several months the wraps should be removed at a time when the dried-out patches show clearly the extent of damage. All dead bark should then be carefully cut away and injured areas thoroughly

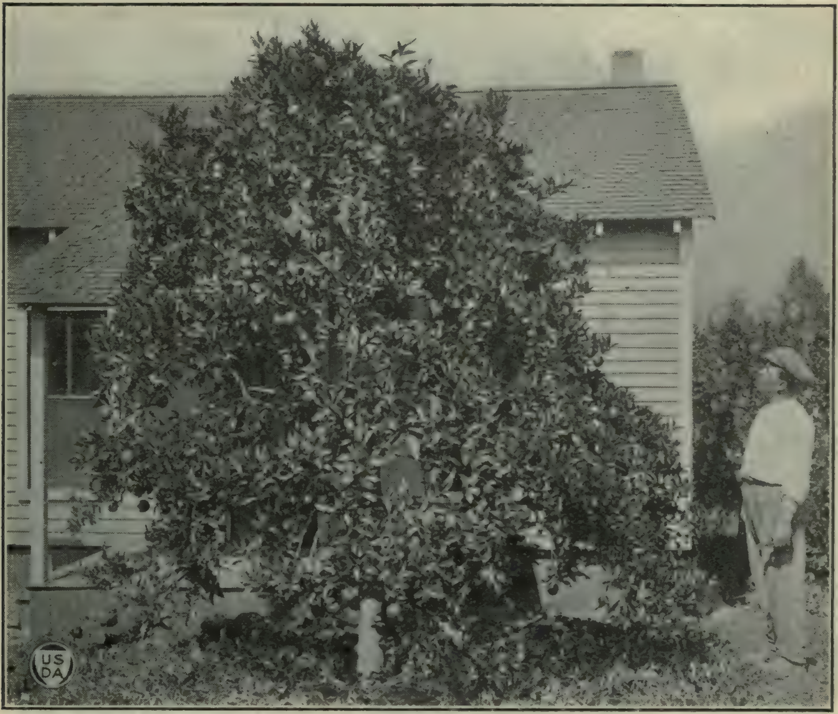

FIG. 10.—Severely pruned Washington Navel orange tree, showing the exposure of the fruits to sunburn, wind damage, and other injuries. This tree did not recover and attain normal fruit production until three years after the pruning.

cleaned. After cleaning, Bordeaux paste[2] should be applied in order to disinfect the wounds and prevent development of diseases. Small splits on branches or tree trunks can be left untreated, because they will usually heal without any particular care, or if they do not their injurious effect is of little consequence. Cost of treatment will probably be greater than any benefit which might arise from it.

Frosted trees are sometimes pruned before the extent of their injury can be definitely ascertained. In this case pruning often has to be repeated later in the season, thus increasing cost. Furthermore, when the injured growth is removed immediately following a freeze climatic conditions may be such as to encourage new growth, which is likely to be killed or badly hurt by subsequent frosts. If injured trees are left until new growth has started during spring and early summer months, injured branches can be safely cut out. If trees are largely defoliated by reason of low temperatures, trunks and branches should be covered with whitewash to protect them from sunburn. A badly frosted and defoliated Eureka lemon tree is

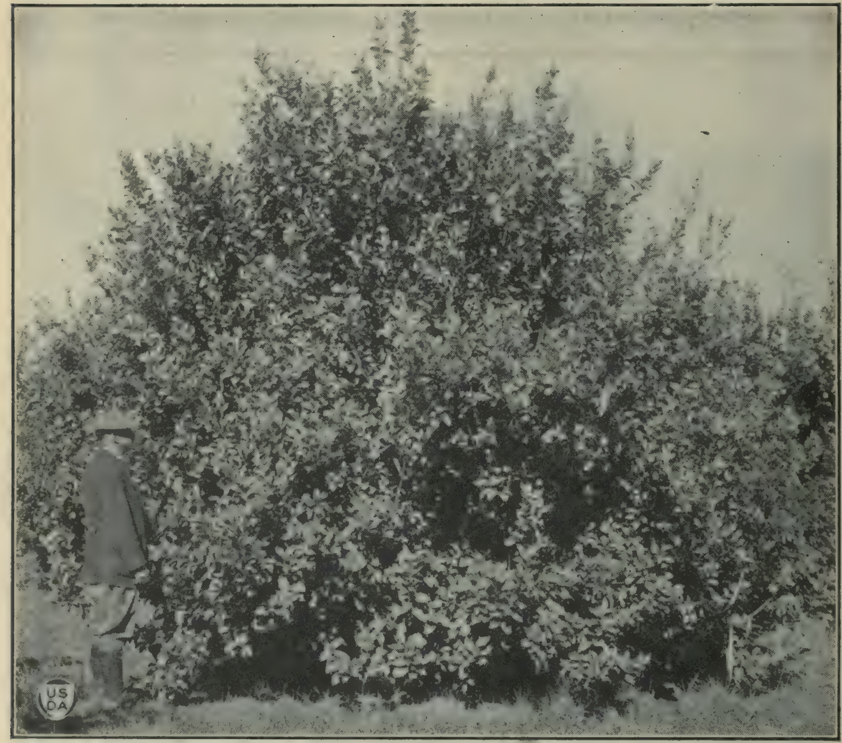

FIG. 11.—Unpruned Eureka lemon tree 11 years old, for comparison with Figure 13.

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[2] The standard formula for Bordeaux paste is as follows: Dissolve 1 pound of bluestone (copper sulphate) in 1 gallon of water in a wooden or earthen vessel. This can best be done by hanging it in a sack near the top of the water. Slake 2 pounds of quicklime in about half a gallon of water. Stir together when cool, making a light-blue mixture of about the consistency of whitewash. If the mixture turns to some other color before application it is an indication that something is wrong. Mix a fresh supply every day or two, as the mixed paste tends to deteriorate with age. Apply with a brush.

shown in Figure 15. A pruned frost-injured Eureka lemon tree is shown in Figure 16. New growth of the pruned tree one year after pruning is shown in Figure 17. Figures 18 and 19 show the recovery in neighboring Washington Navel orange groves of typical trees which were properly and poorly pruned, respectively, following a severe freeze. In lightly frosted bearing trees small injured branches may be removed after danger from further frost damage has passed.

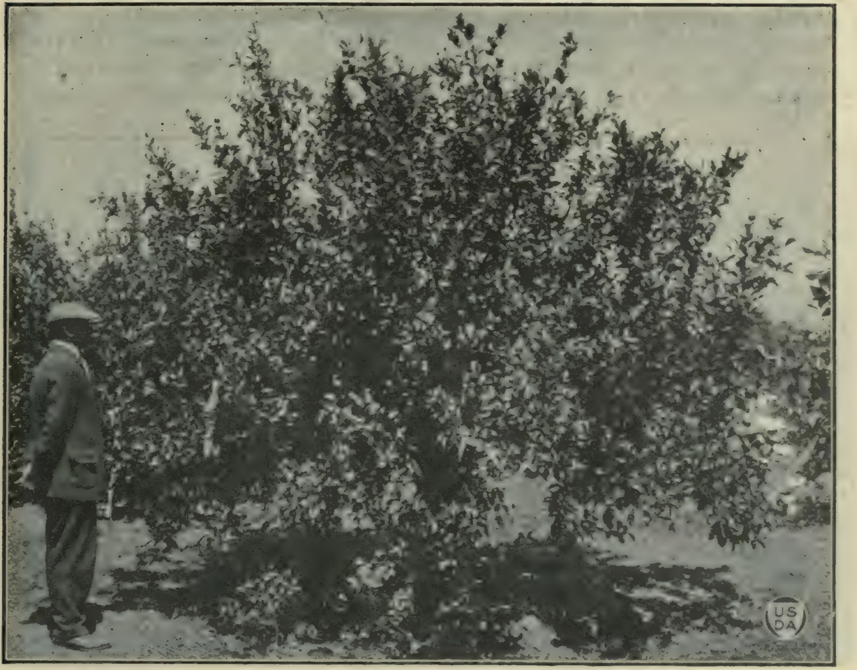

FIG. 12.—Lightly pruned Eureka lemon tree 11 years old. Compare this with the unpruned tree shown in Figure 11.

PRUNING DISEASED AND INJURED TREES.

The most common fungous diseases attacking citrus trees in California and Arizona include brown-rot, or Pythiacystis gummosis (*Pythiacystis citrophthora*); mal di gomma, or foot-rot; and psorosis, or California scaly bark, which occurs mostly on oranges and sometimes on grapefruit.[3]

The portions of trees injured by these and similar diseases oftentimes may be successfully treated by carefully cutting away the diseased tissues and applying suitable antiseptic materials, such as Bordeaux paste. Smaller branches suffering from these diseases can usually be pruned off, taking care to make the cuts well back of diseased areas. This work usually requires special experience, and it is generally most economical to secure trained pruners for it.

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[3] A description of the injuries caused by these diseases is given in Bulletin No. 262 of the California Agricultural Experiment Station, Citrus Diseases of Florida and Cuba Compared with Those of California, by Howard S. Fawcett.

Small branches which have been badly injured or killed as a result of insect attack should be pruned off and the cause of the injury eliminated. This pruning will usually stimulate active new growth and hasten the recovery of the affected trees. In trees partly defoliated and badly injured by scale attack, judicious pruning before fumigation will usually prove to be beneficial in stimulating new and vigorous growth.

Tree trunks or large roots girdled or partly girdled by mice, gophers, or other rodents can usually be treated successfully if the treatment is done soon after the injuries have been made. Trees with badly girdled trunks generally can be saved by inarching or bridge grafting. The inarching process is illustrated in Figure 20.

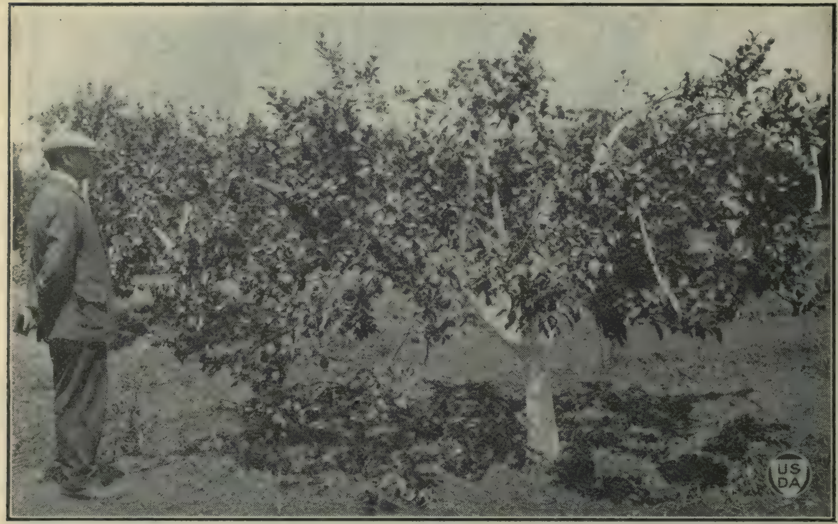

FIG. 13.—Heavily pruned Eureka lemon tree 11 years old, for comparison with Figure 11.

Injured edges of the bark of partly girdled trunks should be smoothed, the wounds covered with grafting wax or similar protective material, and the trees pruned severely. If injured trees have been seriously affected, it is usually desirable to cut them back during the early spring months, somewhat in proportion to the degree of injury. These injuries are frequently accompanied by partial defoliation of the trees, in which event the trunks and main branches should be coated with whitewash in order to protect them from sunburn.

Large branches are sometimes broken by cultivators or other implements of tillage. These branches should be cut off as soon as the injuries are discovered, in order to avoid further possible damage to the trees.

SEASONS FOR PRUNING.

The season best adapted for pruning depends to a considerable degree upon the character and object of the work. The time for heading young trees depends largely upon when the budding was done and upon growth conditions. Trees which are budded in fall and early spring can usually be headed during the first summer. Late spring and early summer budded trees are usually headed during the same summer or early the following spring. As a rule, young trees should be headed when they reach the proper height and when the branching growth stimulated by heading is not likely to be injured by frost or extreme climatic conditions. Spacing the growth stimulated by the heading-back process is done usually the same season as heading back, but sometimes this work is deferred until the following season.

The removal of suckers, crossed limbs, or other objectionable branches is usually done during late winter or early spring, when the trees are in their most dormant condition. Thinning bearing branches in order to stimulate the rate of growth of fruits or to influence their size is usually done while the fruits are small and immature during spring or early summer.

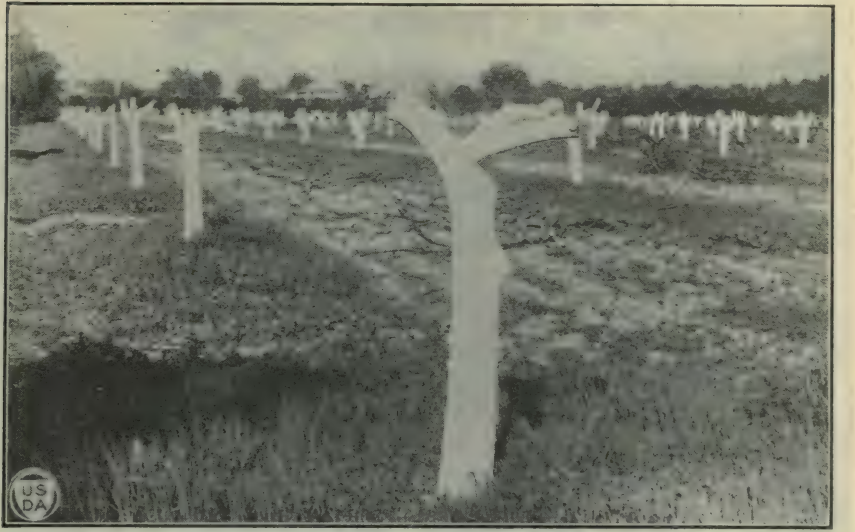

FIG. 14.—Neglected and decadent Washington Navel orange trees cut back very severely in order to grow new tops. The pruning was done in February, 1914, and was followed by thorough cultivation and liberal fertilization of the soil. These trees grew satisfactory new tops and recovered normal fruit production within five years. It is sometimes questionable whether or not this extreme treatment is more desirable than to replant the orchard with young trees.

Control of the growth of leaders and other growth to secure strong and well-balanced trees and to keep the development of tree tops so that the fruits can be conveniently picked is usually effected by pruning during late winter or early spring after danger of frost injury has passed. Location of the orchard with relation to frost damage is an important factor in determining the time for carrying on this work.

The cutting out or other treatment of branches seriously damaged by fungous diseases or insect pests is usually done whenever these conditions are discovered. Whenever possible, this work should be done during late winter or early spring.

The renewing of old, neglected, or decadent trees by severe pruning should be done during late winter or early spring, so that growth stimulated by this pruning is not likely to be injured by excessively low or high temperatures or other weather hazards.

In general, the seasons selected for pruning citrus trees in the Southwest in order to secure the best results should be governed by the location of the orchard with respect to frost, heat, or wind injuries, the age and condition of fruits borne by the trees, the characteristics of growth to be removed, the relation of this work to other orchard activities in order that labor may be employed most efficiently and economically, and the local experience showing the best results from a particular season for this work.

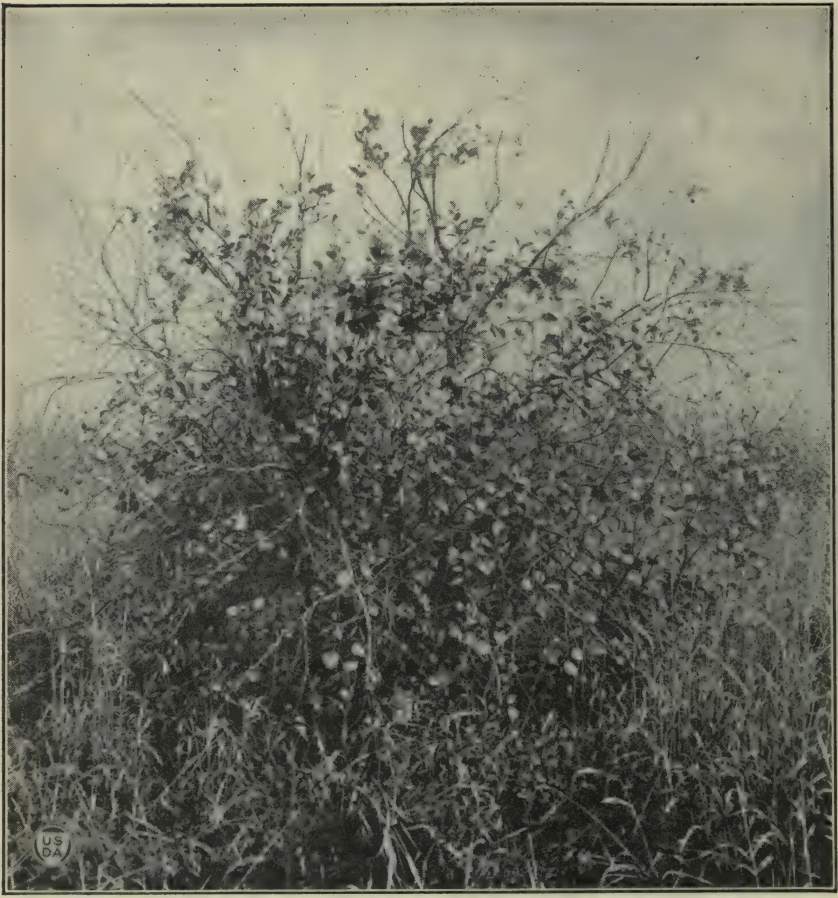

FIG. 15.—A Eureka lemon tree severely injured by low temperatures, showing its defoliated condition immediately after the freezes of the winter of 1912–13.

PRUNING METHODS AND PRUNING TOOLS.

The art of pruning includes efficient handling of pruning tools, intelligent selection of branches to be cut out so as to leave well-distributed growth in the tree top, making smooth cuts at the proper location and angle so that the cut surfaces will heal over without subsequent damage to the trees, protection of pruned trees from sunburn, and treatment of wounds caused by pruning in order that they may be protected from infection by disease. Suitable pruning implements are needed to make good cuts. The treatment of cut surfaces immediately after pruning aids in the callusing and healing over of wounds.

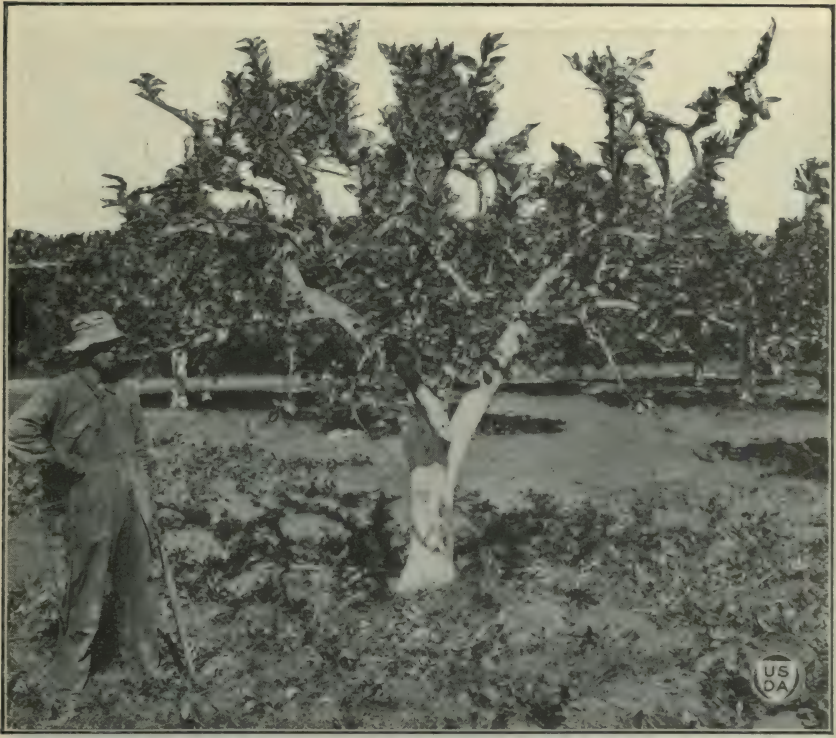

FIG. 16.—Eureka lemon tree badly injured by low temperatures and severely pruned three months after the frost, in order to remove the dead and injured growth. The condition of this tree one year later is shown in Figure 17.

PRUNING IMPLEMENTS.

The most commonly used and most efficient citrus-pruning implements and supplies include (1) long-handled shears; (2) short-handled shears; (3) saw; (4) ladder; (5) file, whetstone, and repair tools; and (6) long leather gauntlets.

Cutting and sawing implements should be kept sharp and in the best possible condition for making smooth and clean cuts. For this purpose it is advisable to have whetstone, files, or other sharpening tools in a bag or box convenient for frequent use in the field during pruning work. Wherever possible, it is advisable to secure shears and saws with replaceable cutting or sawing parts. In this way the cutting or sawing blades when badly worn can be replaced with a minimum of expense. Typical implements suitable for this work are shown in Figure 21.

It has also proved economical in the long run to buy cutting and sawing implements of the best grade of steel. Such implements not only last longer than inferior ones but also enable the pruner to make more rapid and efficient cuts and thereby accomplish better work than with tools of lower grade.

Pocket or other knives with large blades, similar to those shown in Figure 21, a chisel, and a gouge with cutting edges of suitable shape can sometimes be used to advantage in smoothing the surfaces of large cuts or in cleaning out diseased tissues. Cuts with smooth surfaces and edges callus and heal over more rapidly than those having rough surfaces or ragged edges.

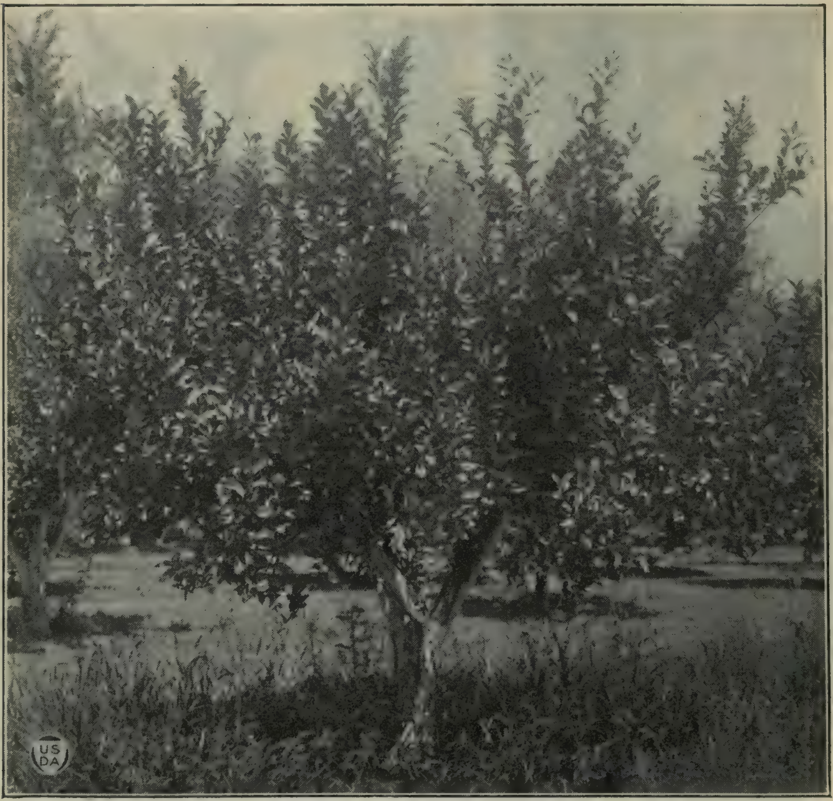

FIG. 17.—Eureka lemon tree, showing the growth of one year following severe pruning to cut out frost-injured branches. The condition of this tree immediately following the pruning is shown in Figure 16.

Repair or replacement parts, sharpening devices, and extra implements should be kept on hand in the orchard where work is being done. Tools in actual use should be gone over frequently by some one capable of repairing or adjusting them in order to keep them in condition for use as nearly perfect as possible.

Long strong leather gauntlets are essential in citrus work, in order to protect the pruner's hands and arms from injuries by thorns or sharp branches.

Orchard ladders for reaching parts of trees not easily accessible from the ground are necessary for good pruning. These ladders should be as light as is consistent with adequate strength and should have three legs, so as to stand firmly in a convenient position for reaching the growth to be removed. Such ladders are easily moved about and can be quickly placed in convenient positions for pruning.

PRUNING CUTS AND THEIR TREATMENT.

The art of pruning includes making smooth cuts at the proper angle and in the right position. When it is necessary to remove large branches the cuts should be made as close as possible and parallel to the limbs or trunks of the trees from which arise the branches to be removed. Stubs or projecting ends should be avoided in every possible instance. Square cuts with horizontal exposed surfaces are very undesirable as a rule. Bruises, scratches, and other injuries to the bark or growth of the tree back of the cuts or elsewhere made by pruning implements, shoes, or from other causes indicate very poor pruning practice, and great care should be used to avoid them.

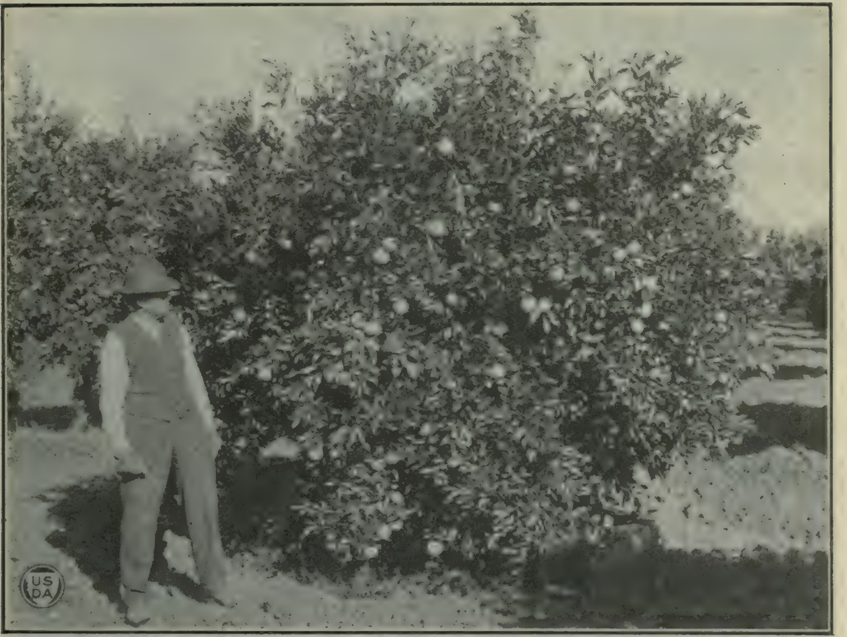

FIG. 18.—A Washington Navel orange tree two years after having been properly pruned following a severe freeze.

Improperly made cuts are usually due to inexperience in pruning, carelessness on the part of pruners, dull or defective pruning implements, or by reason of attempting to make cuts from a wrong position. Damage to the future development of trees from poor cuts is likely to be very great. The writer is familiar with many instances in citrus orchards where trees have become diseased following poorly made pruning cuts. The treatment of such trees in order to cut out the decayed wood which developed as a result of disease infection has cost the owners several dollars per tree for their subsequent treatment and care. These trees were often found to be so seriously diseased and injured that they had to be removed from the orchard.

When it becomes necessary to remove large branches careful work is required in order to avoid splitting them and injuring the trees.

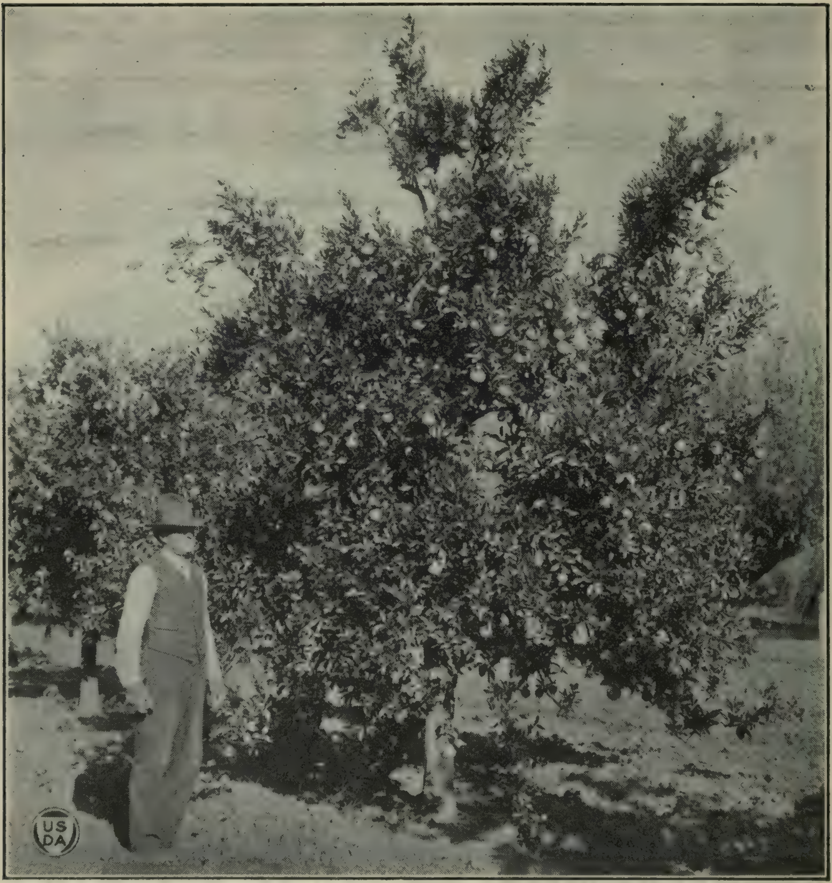

FIG. 19.—Washington Navel orange tree two years after having been poorly pruned following a severe freeze. This tree is located just across the street from the one shown in Figure 18.

In this work the under side of the branch should first be cut part way through with the saw, usually about one-quarter of the diameter of the limb, as shown in Figure 22. Then the upper cut with the saw should be made a little forward of the under one. In this way the branches will break off when nearly or quite sawed through without any danger of splitting or injuring the tree limbs or trunks. After the large limbs have been removed stubs remaining should be sawed off close to the trunk or limb from which the branch was removed and the surface and edges of the cut should be carefully smoothed with a knife or chisel, as shown in Figure 23, in order to facilitate the healing over of the wound. A large pruning cut partly callused and healed is shown in Figure 24.

Small cuts made in pruning citrus trees, those of half an inch or less in diameter, can usually be left without treatment under the climatic conditions of the Southwest. General experience in pruning is that the larger cuts should be protected by covering freshly cut surfaces with grafting wax or other suitable material. In some instances large unprotected cut surfaces have healed over without protection in an apparently satisfactory manner; as a matter of safe practice, however, wounds of more than half an inch in diameter should be protected. The expense of this operation is small, and

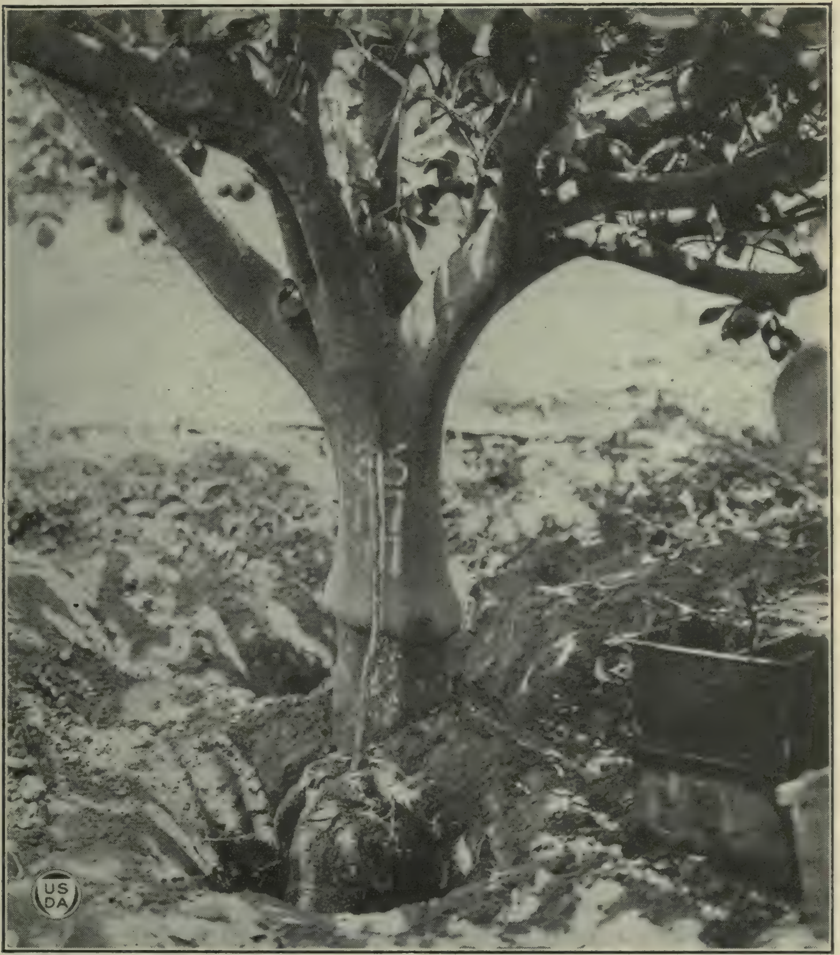

FIG. 20.—Inarching a lemon tree. The seedling sour-orange trees used for the inarching process are set in holes near the tree trunk, and long contacts of the cambium layers of the seedling stems and the tree trunks are made. A homemade arrangement for keeping the wax warm and soft is shown at the right.

the insurance against decay developing from larger cuts justifies this practice.

Several protective materials have been commonly used in covering pruning cuts and tree injuries in citrus trees in the Southwest, including grafting wax, asphalt paint, tar, and several proprietary compounds. Of these, grafting wax has given the most universal satisfaction. The method of preparing grafting wax for use in protecting tree wounds varies greatly, according to the ideas and experience of the individual pruners and users. A standard method is to melt together 1 part of tallow, 1 part of beeswax, and 2 parts of rosin. This wax should be stirred or pulled until it develops a yellow grain. It will keep indefinitely. An experienced California citrus pruner uses a grafting wax for covering tree wounds made by melting together equal parts of beeswax and rosin. For inarching, the mixture is made up of 2 parts of beeswax to 1 of rosin. During use a quantity is kept warm and plastic by heating it with a slow fire, in which condition it can be applied with a brush. Care should be exercised to cover fully all of the wounded area.

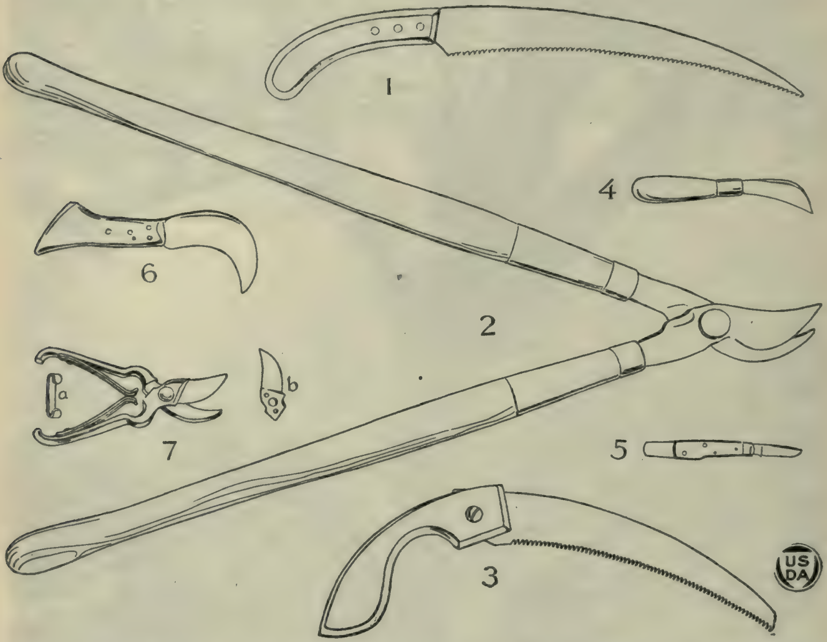

FIG. 21.—Pruning implements used in connection with the management of citrus trees: 1, A sharp-pointed type of saw; 2, long-handled shears for the removal of large limbs; 3, a folding saw frequently used because it can be conveniently carried; 4, a pruning knife; 5, a budding knife; 6, a heavy hawk-billed knife; and 7, short-handled pruning shears (*a*, clasp; *b*, extra blade).

The stove or other arrangement for use in heating grafting wax or similar materials and keeping them in condition for application can frequently be made out of a small worn or cast-off household stove or burner. A large square metal oil can is frequently arranged for this purpose, a lower pan holding the fire and an upper pan the material to be warmed. A homemade arrangement of this sort is shown in Figure 20. An ordinary paintbrush is needed for applying the melted grafting wax or other similar materials to the freshly cut surfaces.

The failure to protect large cuts made during pruning sometimes leads to decay or heart-rot in the trunks or main limbs. In this event it is necessary in order to save the trees to dig out and clean the decayed areas carefully. If the cavities are small the surfaces should be covered with grafting wax, tar, or other suitable material after the removal of all decayed tissue. If the cavities are large they should be thoroughly cleaned and then disinfected with some effective material such as creolineum, after which they may be filled with cement. The treatment of heartwood rot in citrus trees resulting from careless pruning is very expensive, so that every precaution should be taken to avoid the necessity for it.

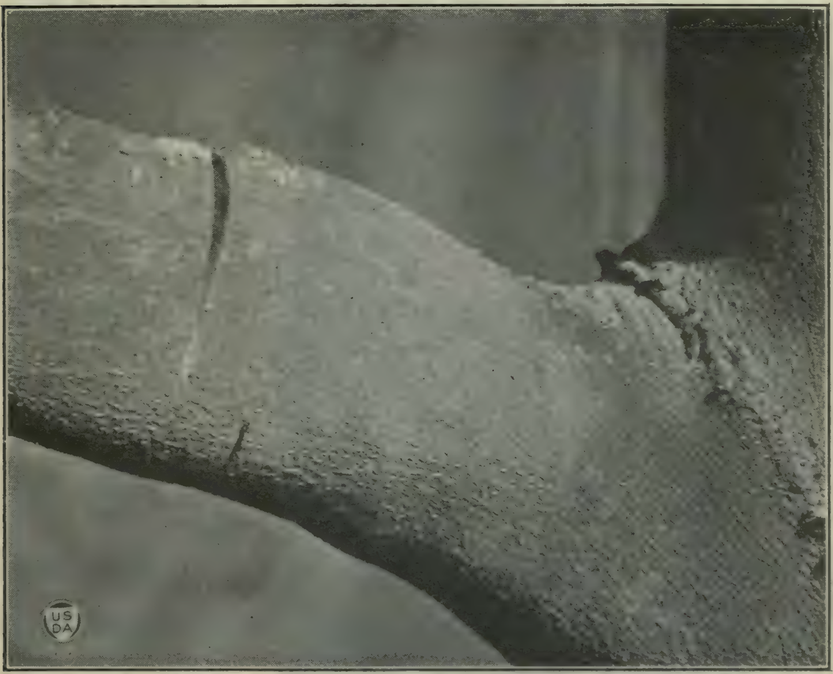

FIG. 22.—Sawing off a large citrus limb. The first cut is made on the under side. The cut on the upper side is made in front of the under one, so that when the limb breaks off there is no danger of splitting or injury to the tree. The stub thus made is then cut off at the proper place, as shown in Figure 23.

CARE OF PRUNED TREES.

Lightly pruned citrus trees in the Southwest require no particular care after pruning. Severely pruned trees, where considerable of the growth has been cut out, do need some protection from sunburn, wind, or other exposure. In the case of small trees the heavily pruned ones may be protected to advantage by wrapping the trunks with burlap or other cloth, paper, or similar wraps, arranging the wraps so as not to restrict the growth of the trees in any way. Cloth or paper wraps can usually be wound about the trunks in a spiral way and loosely tied, so that they will easily give way to the expansion of the trunks. It is also important to inspect the bark under such wraps occasionally, in order to make sure that they do not harbor scales or other insect pests or encourage the development of fungous diseases. Trunks and main limbs of larger citrus trees should be covered with whitewash as soon as possible after severe pruning is done.

It is a mistake to assume that heavily pruned trees do not require fertilization or other usual cultural care. They should be given adequate care to hasten their recovery and promote their best development. If pruned trees are left for a year or more without systematic cultural attention a spindling and undesirable growth condition is likely to develop.

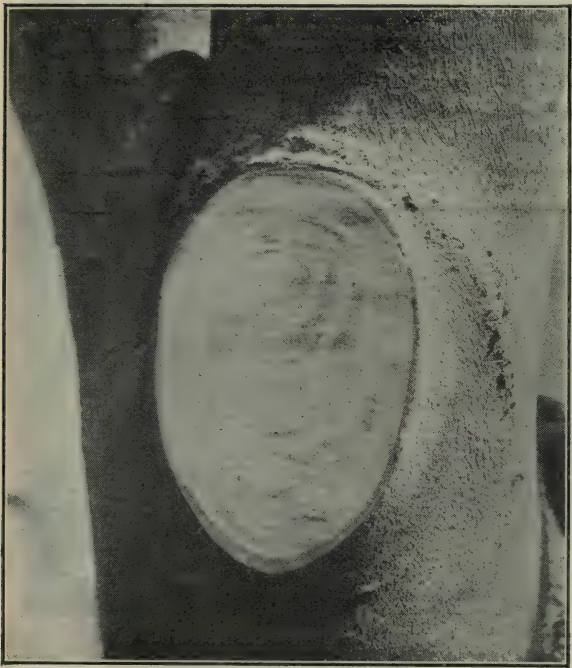

FIG. 23.—A smooth surface and close cut made in sawing off a large citrus limb. The cut is parallel to the tree trunk. It was covered with grafting wax immediately after the operation.

INDIVIDUAL TREE CARE.

In order to give citrus trees individual care in pruning it is advisable to number every tree, so that each particular tree needing attention can be found and treated at the proper time. The tree-numbering system which has given best results is as follows: Each tree is given a number consisting of three parts—(1) number of the orchard or block, (2) number of the row in which the tree occurs, and (3) position of the tree in the row, always counting from some fixed point, such as irrigation head or other permanent landmark. A tree located in block 6, row 12, and the sixteenth tree in the row will have the number 6–12–16. This number can usually be painted upon the tree trunk, using pure white-lead paint and a lettering brush. The numbers should always be placed in the same relative position on the trees, so as to be easily found at any time. The figures should be plain and as large as possible, in order to simplify their identification. On larger tree trunks the numbers can be arranged in a vertical position, one part below another, as
6
12
16.

With very small trees each figure can be placed in a vertical column, with dividing lines between the parts of each number.

In all orchard-inspection or cultural work where individual trees are observed with broken limbs, objectionable branches, or attacked by fungous diseases, insect pests, or rodents, the numbers of trees needing attention can be recorded in a field notebook. When the proper time for pruning and treatment arrives or when opportunity offers, the trees needing treatment can be found with certainty and without loss of time by aid of the tree numbers.

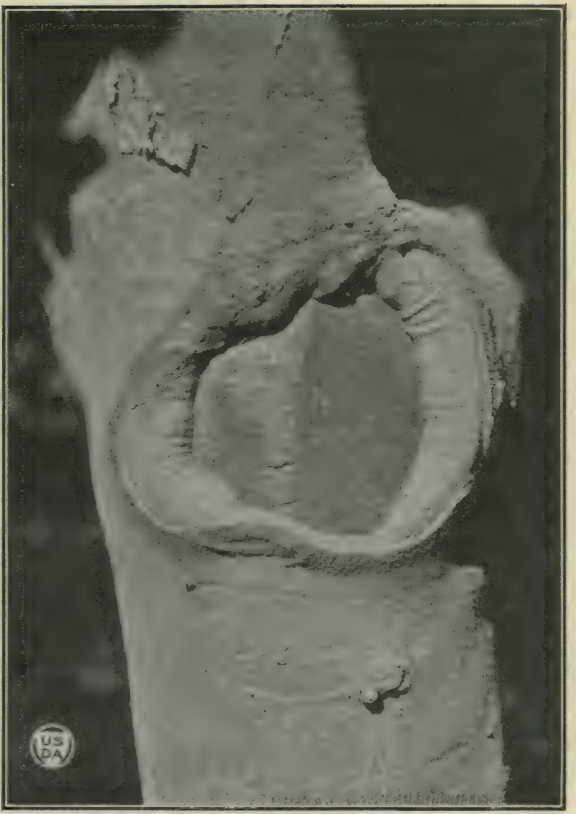

FIG. 24.—A large wound made in pruning, showing the extent to which it had healed three years after it was made.

FREQUENCY OF PRUNING.

Frequency of pruning depends largely upon the inherent characteristics of trees, soil, and cultural and climatic conditions, particularly with reference to possible frost and heat injuries and in some degree with relation to season of fruiting.

With inherently fruitful strains of citrus varieties the necessity for frequent and severe pruning is largely eliminated.

Trees growing on very rich soil and under favorable cultural conditions, promoting active vegetative growth, may need more frequent pruning than those planted on lighter soils or those having less fertilization or inferior cultural treatments.

Frost and heat injuries must be treated by pruning at the proper time. The pruning of citrus trees in locations where frost or heat injuries are to be expected should be such as to minimize the stimulation of tender vegetative growth likely to be hurt by subsequent adverse weather conditions.

Severe pruning should not be done frequently, usually not oftener than once during a period of several years. This pruning when done during late winter or early spring should be followed later in the same season with thinning and other care of the growth stimulated by the pruning.

It seems likely that all citrus trees should be gone over at least once every year in order to give them any necessary pruning treatment, such as removing objectionable growth, control of the framework in order to secure well-balanced tops, and to cut out dead and decadent branches.

DISPOSAL OF PRUNINGS.

Citrus prunings in California and Arizona orchards have usually been disposed of in the following ways: (1) By burning, (2) by piling them under the trees, and (3) by cutting them up and plowing or disking them into the orchard soil.

The practice of burning prunings from citrus trees has largely been abandoned in the Southwest, except in the case of growth which is known to harbor insect pests or that attacked by fungous diseases. In order to burn the branches cut off during pruning, it has usually been necessary to haul them out of the orchard to a safe distance, so as to avoid possible heat damage to the trees. This method is usually considered to be a wasteful one, and most growers now use the prunings for improving orchard soil conditions.

A considerable number of citrus growers in the Southwest have tried the plan of piling prunings under the trees. It was thought that by using this method the prunings would decompose slowly and act as a mulch for the soil under the trees, thus preventing weed growth and keeping these soil areas in good tilth. Owing to the tendency of field mice and other rodents to hide and nest under prunings disposed of in this manner and the serious injuries to the trees from girdling under these circumstances, this method generally has been given up.

The most satisfactory method of disposing of citrus-tree prunings in California and Arizona is to incorporate them in the orchard soils. In small orchards the larger limbs can be cut up into pieces so small that they can be plowed or disked under and satisfactorily covered.

In larger orchards, where the prunings from a large number of trees are to be cut up, this work can be most economically done by running them through a suitable cutting machine, such as a silage cutter. This machine can be mounted on a movable truck with a gas engine to operate it. The prunings are run through a cutter so arranged as to cut them up into small pieces which can be easily plowed or disked under. When pruning is done during winter or early spring before plowing or cultivation has begun, the prunings can be cut up and distributed over the soil between the trees at the time of pruning. The partly decomposed prunings can be plowed or disked under later or at the regular season for this work.

COST OF PRUNING.

In a citrus orchard located at San Dimas, Calif., which contains 21 acres of Eureka lemon, 17 acres of Valencia orange, and 6 acres of Marsh grapefruit trees, or a total of 44 acres, the total expense of pruning the trees for the first five and a half years after planting was $358.35. The total pruning cost in this case amounted to an average of $8.14 per acre, or an average annual expense of $1.48 per acre from the time the orchard was planted in the spring of 1916 to the autumn of 1921. The expense of pruning for the first two years in this orchard was very light. The trees were all grown from buds secured from superior parent trees selected for propagation on the basis of their performance records.

The cost of pruning ordinary young citrus trees, particularly those of the vegetative strains, is much higher than that shown for the superior fruitful-strain trees mentioned in the foregoing statement.

The cost of pruning citrus trees varies so much, on account of the system of pruning used, because of the different rates of wages paid to pruners in different districts, and by reason of the fact that the time required to prune trees varies with regard to individual-tree characteristics and seasonal growth conditions, that no definite statement of expense can be presented which will apply to all orchard conditions. Under ordinary orchard conditions with normal healthy trees the annual cost of pruning full-bearing orange and grapefruit trees has amounted to about $10 per acre and for full-bearing lemon trees to about $20 per acre.

The important fact should be noted that the expense of pruning inherently fruitful citrus trees is very much less than that of pruning the rank-growing unfruitful and vegetative trees illustrated in Figure 8. This difference is a very important item in the cost of orchard maintenance and should be given careful consideration by every prospective citrus planter.

EFFECTS OF PRUNING.

The effects of pruning upon bearing citrus trees include (1) stimulation of vegetative growth, (2) increase of rate of growth of the fruits, and (3) reduction of yield. The effects vary somewhat in proportion to the severity of pruning with regard to cultural and individual tree conditions and other factors. The desirability of any pruning practice can best be determined through a study of the effect of pruning upon behavior of the trees.

EFFECT OF PRUNING UPON TREE GROWTH.

Pruning citrus trees, particularly severe pruning, stimulates vegetative growth. When a part of one of the larger branches is cut off, dormant buds back of the cuts usually develop and start growth. The rate of growth of these branches is greater than that of the branches on unpruned trees under comparable conditions, at least during their first period of growth.

In the case of severe pruning the pruned trees do not usually reach the same volume as the unpruned trees, or at least not for a considerable period of time. There is some evidence to show that the severe pruning of tops is accompanied by a corresponding slowing up of root development. Therefore severe pruning seems to result in a permanent reduction of size of both top and root areas.

EFFECT OF PRUNING UPON THE GROWTH OF FRUITS.

The rate of growth of fruits borne by pruned citrus trees is usually greater than that of fruits produced by unpruned trees. There is no available evidence to show that the ultimate size of the mature fruits from pruned trees is different from that of the fruits borne by unpruned trees. In lemons, where the fruits are picked before maturing upon reaching a certain size, the influence of pruning upon the rate of growth may be important in that it will enable the grower to stimulate the rate of growth in order to make the lemons reach marketable size at a particular season. Otherwise the importance of pruning citrus trees in so far as it relates to affecting the size of fruits is almost negligible.

EFFECT OF PRUNING UPON FRUIT PRODUCTION.

The effect of light pruning, such as the removal of suckers and dead or decadent branches, upon the yield of citrus trees is usually almost negligible. If healthy fruit-bearing growth is cut out the yield is almost certain to be lowered.

The effect of severe pruning upon healthy bearing citrus trees has usually reduced the production of fruit about in proportion to the severity of the pruning. Unless there are apparent compensating advantages in tree growth or shape it seems that such pruning should be avoided with normal trees. The loss in yields is usually brought about through the reduction of the leaf area, with a consequent loss of power of carbon assimilation, and by the unnecessary cutting off of fruit-bearing growth.

Thinning the fruits by pruning has shown little or no apparent improvement in the ultimate size or the commercial grade of the ripe fruits. Where trees have a large number of dead branches which might injure the adjacent fruits through scratches or bruises, it seems certain that under most circumstances this growth should be removed by careful pruning. It is questionable from an economic standpoint whether it is profitable to cut out small numbers of dead branches unless they favor the development of fungous diseases or harbor insect pests.

SUMMARY.

The principal objects of pruning citrus trees are to train the growth of young trees so as to provide a strong well-balanced framework, to remove objectionable branches, to thin the growth, to control diseases, to aid in the recovery of trees from insect or other injuries, and to renew old and decadent trees.

Young citrus trees should be headed in the nursery or when they reach a height of about 30 inches above the ground.

The main framework branches should be arranged in a spiral around the tree trunk several inches apart and should consist of not less than three nor more than five limbs.

Two methods of arrangement of framework limbs stand out as the dominant ones as a result of experience in this connection. One provides for training these limbs in an upright position, commonly called a vase shape, which seems to produce stronger trees, more resistant to adverse weather conditions. The other has for its object the development of spreading and comparatively low growing trees, usually referred to as having a bowl shape, more easily treated for insects and diseases, and providing for easily accessible fruits.

The early fruit-bearing growth of young trees should be left undisturbed, so as to encourage early fruiting.

Full-bearing healthy orange and grapefruit trees should not be pruned except to remove dead or decadent growth, to remove suckers or objectionable branches, and to guide the development of a strong and balanced tree top.

Full-bearing healthy lemon trees should be pruned along the same lines as similar orange and grapefruit trees, except where it is desirable to hasten the rate of growth of the fruits in order to market them at a particular season.

Old or decadent trees which have become somewhat unproductive by reason of the condition of the vegetative growth may sometimes be renewed by cutting off the old tops and growing new ones. The method of cutting back such trees and caring for the new growth is similar to that in the case of top-worked trees.

Frost-injured trees should not be pruned until sufficient time has elapsed after the freeze so that the lines of demarcation between the injured and healthy areas can be clearly determined. Killed and badly injured branches should be removed and split-bark patches in the trunks or main limbs treated in order to hasten recovery and prevent fungous infection.

The best season for citrus pruning in the Southwest is during the spring and early summer. Follow-up thinning and related work usually can best be done during early summer.

The most important pruning implements are a saw, a pair of long-handled shears, a pair of short-handled shears, a ladder, and strong gauntlet gloves to protect the hands and arms of the pruners.

Pruning cuts should be carefully made, so as not to injure the bark or wood of the tress. Smooth sloping cuts are evidence of experienced work.

All of the larger pruning cuts should be covered with grafting wax, asphalt paint, or similar material as soon after the cuts have been made as possible. Small cuts need not be treated in this way.

Pruned trees should be given adequate fertilization, irrigation, and cultural treatments. Pruning is not a substitute for any phase of cultural care.

All severely pruned or otherwise partially defoliated trees where the trunks or branches are exposed to the sun and weather should be coated with a suitable whitewash.

Each tree, on account of the individuality of trees, should be treated with regard to its particular requirements and apparent needs.

The frequency of pruning depends upon circumstances. Usually a severe pruning is necessary under normal conditions only after long intervals. Light pruning may be desirable every year or rather frequently, depending upon local orchard conditions.

Pruning stimulates the rate of growth of citrus fruits.

It has been demonstrated through extensive experimental and commercial citrus-orchard experience during the past 10 years that trees propagated from fruit-bearing budwood secured from superior performance-record parent trees of fruitful strains require but little pruning under normal conditions.

The use of a systematic individual-tree numbering system greatly facilitates and aids in pruning and related work.

In order to decide intelligently on pruning practices, growers should keep individual-tree records of production of a few pruned trees for comparison with the behavior of unpruned trees.

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FARMERS' BULLETIN No. 1334

Rev. Jan '40

HOME TANNING OF LEATHER AND SMALL FUR SKINS

1862 1889

ORDINARILY hides and skins should be tanned only by experienced tanners. Sometimes and in some places, however, the spread between the receipts for hides and the cost of leather warrants the farmer in tanning for himself.

The inexperienced can not hope to make leather equal in appearance, or possibly in quality, to that obtainable on the market, but farmers and ranchmen should be able to make serviceable leather for most farm purposes by carefully following the directions here given.

It is never advisable for an inexperienced person to try to tan valuable fur skins or large hides to be made into coats, robes, or rugs. The results would be disappointing, both in appearance and in quality. Small fur skins or skins of low market value, however, can be tanned for home or country use according to the directions given in this bulletin.

Washington, D. C. August, 1923

HOME TANNING OF LEATHER AND SMALL FUR SKINS.

R. W. Frey, *Associate Chemist*, I. D. Clarke, *Assistant Chemist*, and F. P. Veitch, *Chemist in Charge, Leather Investigations, Bureau of Chemistry.*

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THE TANNING of a few hides and skins by inexperienced persons or by those lacking proper equipment is usually inadvisable, from the standpoint both of national economy and of individual profit. Tanners are equipped to make all the leather that the country needs. They can make leather of a better quality and can do it more economically than can the farmer. Under normal conditions, then, farmers and ranchmen should try to improve the quality of the hides and skins that they produce and to market them advantageously, leaving to tanners those trade operations which call for time and equipment and which often result in loss of hides and labor when undertaken by those who have had no experience in the work.

HAVING HIDES TANNED.

It may be more economical to have hides and skins tanned by tanners who are willing to tan one or more hides than to do the work on the farm or ranch. Some tanners tan only hides with the hair on for robes or coats; some also tan harness, strap, lace, and glove leather; others tan only harness, strap, or lace leather; a few tan sole leather. Some accept one-half of the hide in payment for tanning the other half. That is, if a farmer sends a hide to be tanned, the tanner will send back one-half tanned into leather, keeping the other half to pay for his work. This probably is the best way for farmers to get their leather.

Depending on the size of the hide, the kind of leather, and the tanner's prices and profits, the charge for tanning a hide with the hair on or making it into leather varies from $1.50 to $4 for calfskins, and from $5 to $8 a hide, or from 25 to 50 cents a square foot or a pound, for horse and cattle hides tanned into harness, lace, or glove leather.

Definite prices can be obtained directly only from a tanner. In writing to tanners be sure to state exactly what kind of hides you have. Give the weight of each, and ask for prices for tanning them with the hair on, making them into robes or coats, or for tanning them into the kind of leather you want. The hide you have may not be suitable for the kind of leather you want. It takes a 50-pound or heavier hide to make sole or harness leather. If you tell the tanner what you have, he can tell you what it will make. A list of tanners who tan leather and furs for farmers may be obtained by writing to the Bureau of Chemistry, United States Department of Agriculture, Washington, D. C. In supplying this list of names and addresses the department assumes no responsibility for the reliability or quality of work of these tanners. The list simply gives the names of all who have informed the Bureau of Chemistry that they will tan one or more hides for farmers.

As a rule, the tanner does not pay shipping charges either way. These, in addition to the charge for tanning, must be paid by the farmer.

The regulations for shipping hides by express are now very stringent. Express companies will not accept hides for shipment unless they are packed in a keg or other container that does not leak. Consult the nearest express agent about this before shipping.

Be sure to securely tag each hide before it is shipped with your name and address and the kind of leather you wish made from it. Write plainly, using ink or indelible pencil and a tough linen tag with a reinforced eyelet. If the tag comes off or becomes illegible, you probably will lose the hide.

BUYING LEATHER BY THE SIDE.

Many farmers state that they are offered only 1 to 4 cents a pound for hides, but are charged from 90 cents to $1.50 a pound for leather at retail. It may prove more economical in many cases to buy, either individually or cooperatively, leather in quantities larger than a pound or two.

On June 1, 1923, the wholesale prices for leather made from country hides were quoted about as follows: Sole leather in sides, 25 to 35 cents a pound; harness leather in sides, 30 to 50 cents a pound; calf upper leather, 25 to 45 cents a square foot; lace leather, about 20 cents a square foot. Leather made from packer hides usually sells for more than that made from country hides. Wholesale prices fluctuate from time to time. Definite information on prices at the time of purchase must be obtained from dealers or tanners.

By buying a single side of leather as he needs it, a farmer should be able to get it at a price not more than 10 to 20 per cent above wholesale quotations. Of course, expressage on leather bought from tanners must be paid by the purchaser. If whole sides can not be obtained from dealers in near-by cities or towns at satisfactory prices, write the tanners for their prices.

Sole leather is known as oak, union, hemlock, and chrome tanned, and is classed as heavy, medium, and light. For quality it is graded No. 1, No. 2, and No. 3. Chrome sole leather can be bought waxed or unwaxed. Only the waxed is suitable for outdoor use. Harness leather is heavy, medium, and light, and for quality it is graded No. 1 and No. 2, or A and B.

A "side" of leather is half of a tanned hide. It weighs from 15 to 30 pounds, depending upon the size of the hide and the kind of leather. A "back" is a side of leather with the belly, legs, and head trimmed off. Backs cost a little more (3 to 6 cents a pound) than sides. A "bend" is a side of leather with the belly, legs, and shoulder trimmed off. It is the best leather of the hide and is approximately one-half the area or weight of the side. Bends cost more than either backs or sides.

A comparison of the prices at which leather can be bought with the charges for having hides tanned will show which is cheaper. As a general rule, it is believed that it is cheaper to have hides tanned one half for the other.

HOME TANNING.

Sometimes hides and skins can be sold by a farmer or rancher only at prices which are lower than the cost of production. Sometimes "country" hides can scarcely be given away, yet farmers must pay from $1 to $1.50 a pound for leather in small pieces. Under such conditions farmers naturally feel that they must either work up their raw materials or do without the finished leather. As a result, the United States Department of Agriculture has received thousands of requests for directions for farm or home tanning. To meet this demand the following directions have been prepared for tanning one or more hides or skins with only the equipment that can be had on any farm or ranch.

Although good results have been secured in the Bureau of Chemistry by using the equipment and following the directions here given, inexperienced operators probably often will be unsuccessful. Every attempt, however, will add to their experience and should reduce the number of their failures. Operating on a small scale, they can not hope to make leather equal in appearance, and possibly in quality, to that on the market. They should, however, be able to make leather which is serviceable for many purposes on farms and ranches.

The directions for tanning need not be memorized, but they must be studied carefully until thoroughly understood *before the work is begun.* All supplies and equipment should be on hand and all plans should be carefully made before the work is started.

At times it may be necessary to modify these directions, especially those dealing with equipment or tanning conditions or when other kinds of leather are to be tanned. Success in doing this depends largely upon the individual.

Tanning operations are best done at a uniformly moderate temperature. A cellar, which is naturally fairly warm in winter and cool in summer, is a suitable place. A supply of fresh water near at hand and a drain are convenient.

All the operations can be done in tight, clean wooden barrels, preferably oak, having a capacity of from 40 to 60 gallons. When not in use the barrels should be kept clean and full of water. Half barrels and wooden or fiber buckets are useful for many purposes. Iron containers should never be used. Tools useful in tanning are shown in Figure 1.

TANNING HIDES AND SKINS FOR LEATHER.

The kind of leather which can be made from a hide or skin depends largely upon the weight and size of the hide or skin. In the tanning trade distinctions in hides and skins are based mainly upon the size and age of the animal and upon the class of leather. Hides from large and adult animals are suitable for sole, harness, belting, or heavy leathers. Skins from small animals, such as sheep, goats, calves, and deer, are made into light and fancy leathers. While there are other commercially important sources of hides and skins, the most important ones are the usual domesticated farm and range animals. As a general rule, the thickness of the finished leather will be about the same as that of the untanned hide. This should be a guide in selecting skins for different kinds of leather. The first essential for a satisfactory yield of good leather is a sound, clean hide or skin. Skinning should be done properly, without cutting or scoring the hide, at the same time removing all of the fat and flesh which, if left on, increase the tendency of the hide to rot or spoil.

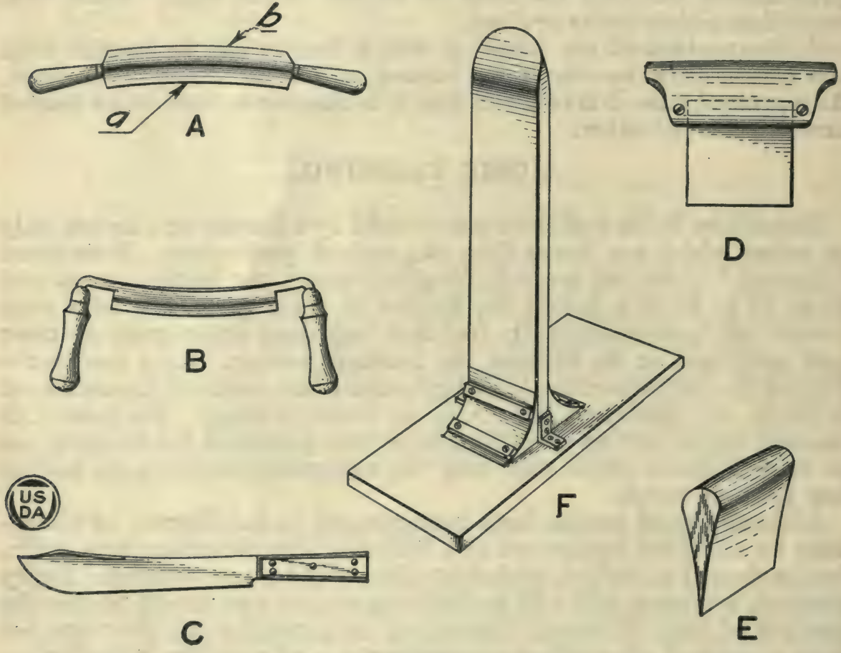

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FIG. 1.—Tools for tanning.

(*A*) Tanner's fleshing knife, having a blade 15 to 17 inches long: (*a*) Dull edge for scraping off the hair after liming; (*b*) very sharp edge for shaving off the flesh.

(*B*) Eight-inch-blade drawing knife which may be used instead of *A*, especially if both handles are bent straight. The back edge may be used for unhairing and the cutting edge for shaving off the flesh.

(*C*) Twelve-inch-blade butcher knife which may be used instead of *A* or *B*, when the point has been driven into a wooden handle or wrapped with leather.

(*D*) Metal slicker—a dull steel blade about 5 inches square, $\frac{1}{32}$ to $\frac{1}{16}$ inch thick, mounted in a wooden handle.

(*E*) Wooden slicker, made of hardwood, about 6 inches square, 1½ inches thick at head, shaved down in the shape of a wedge to a thin edge.

(*F*) Stake for breaking up and softening skins and leather. A board about 3 feet long, 6 inches wide, and 1 inch thick is braced in an upright position to a heavy base or to the floor. The top of the board is rounded and thinned in the shape of a wedge to an edge about ⅛ inch thick.

Farmers' Bulletin 1055, Country Hides and Skins: Skinning, Curing, and Marketing,[1] should be studied in this connection.

Preparation of the hide or skin for tanning may be started as soon as it has been taken off the animal, drained, and cooled from the body heat. Overnight will be long enough. If tanning is not to be started at once or if there are more hides than can be handled at one time, the hides may be thoroughly salted and kept for from three to five months. The hides must never be allowed to freeze or heat during storage or tanning. Some tanners state that salting before tanning is helpful. It can do no harm to salt a hide for a few days before it is prepared for tanning.

The directions here given have been prepared for a single heavy cow, steer, or bull hide weighing from 40 to 70 pounds or for an equivalent weight in smaller skins, such as calf or kip skins. The heavy hides are best suited for sole, harness, or belting leather. Lighter hides weighing from 20 to 40 pounds should be used for lace leather.

PRELIMINARY OPERATIONS.

Before it is tanned a hide or skin must be put through the following preliminary operations, which are the same for all the leather-making processes given in this bulletin. As soon as the hide or skin has been put through these processes, start the tanning, following the directions given for the particular kind of leather desired.

SLAKING LIME.

Put from 6 to 8 pounds of burnt or caustic lime in a clean half barrel, wooden tub, or bucket, with a capacity of at least 5 gallons. Use only good-quality lime, free from dirt and stones; never use air-slaked lime. To the lime add about 1 quart of water. As the lime begins to slake add more water, a little at a time, to keep the lime moist. Do not pour in enough water to quench the slaking. When the lime appears to be slaked, stir in 2 gallons of clean water. Do all this just as in making whitewash. Slake the lime on the day before the soaking of the hide is begun, and keep the limewater covered with boards or sacks until ready to use it.

If available, fresh hydrated lime, not air-slaked, may be used instead of the burnt or caustic lime. In this case use from 8 to 10 pounds in 4 or 5 gallons of water.

SOAKING AND CLEANING.

If the hide has been salted, shake it vigorously to remove most of the salt. Spread it out, hair side down, and trim off the tail, head, ears, all ragged edges, and shanks.

Place the hide, hair side up, lengthwise, over a smooth log or board, and, with a sharp knife, split it from neck to tail, straight down the backbone line, into two half hides, or "sides." It will be more convenient in the later handling, especially when the hide is large, to then split each side lengthwise through the "break," just above the flanks, into two strips, making the strip with the backbone edge about twice as wide as the belly strip. Thus a whole hide will give two sides or four strips. If desired, small skins need not be split. In these directions "side" means side, strip, or skin, as the case may be.

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[1] A copy of Farmers' Bulletin 1055 may be had free upon request to the Division of Publications, United States Department of Agriculture, Washington, D. C.

Fill a 50-gallon barrel with clean, cool water. Place the sides, flesh side out, over short sticks or pieces of rope and hang them in the barrel of water. Let them soak for two or three hours. Stir them about frequently to soften, loosen, and wash out the blood, dirt, manure, and salt. The sticks or pieces of rope may be held in place by tying a loop of cord on each end and catching the loops over nails in the outside of the barrel near the top.

After soaking for about three hours take out the sides, one at a time, and place them, hair side up, over a "beam."

A ready-made beam can be bought. A fairly satisfactory one may be made from a very smooth slab, log, or thick planed board, from 1 to 2 feet wide and 6 to 8 feet long. The slab or log is inclined, with one end resting on the ground and the other extending over a box or trestle so as to be about waist high.

With the side lying hair side up over the beam, scrub off all dirt and manure, using if necessary a stiff brush. Wash off with several bucketfuls of clean water.

Turn the side over, flesh side up, and scrape or cut off any remaining flesh. Work over the entire flesh side with the back edge of a drawing or butcher knife, held firmly against the hide, while pushing away from the body. Wash off with one or two bucketfuls of clean water. This working over should always be done.

Refill the soak barrel with clean, cool water and hang the sides in it as before. Pull them up and stir them about frequently until they are soft and flexible. Usually a green or fresh hide needs to be soaked for not more than from 12 to 24 hours and a green salted hide for not more than from 24 to 48 hours.

When the sides are properly softened—that is, about like a fresh hide or skin—throw them over the beam and thoroughly scrape off all remaining flesh and fat. It is of the greatest importance to remove all this material. When it can not be scraped off, cut it off, but be careful not to cut into the hide itself. Even should there appear to be no flesh to take off and nothing seems to be removed, it is necessary to thoroughly work over the flesh side in this way with the back of a knife. Finally wash off with a bucketful of clean water.

The side must be soft, pliable, and clean all over before being put into the lime, which is the next step.

LIMING.

Wash out the soak barrel. Pour in all of the slaked lime; nearly fill the barrel with clean, cool water; and stir thoroughly. Place the sides, hair side out, again over the short sticks or pieces of rope, and hang them in the barrel so that they are completely covered by the limewater. (Fig. 2.) See that the sides have as few folds or wrinkles as possible and also be sure that no air is trapped under them. Keep the barrel covered with boards or bags. Pull up the sides and stir the limewater three or four times each day until the

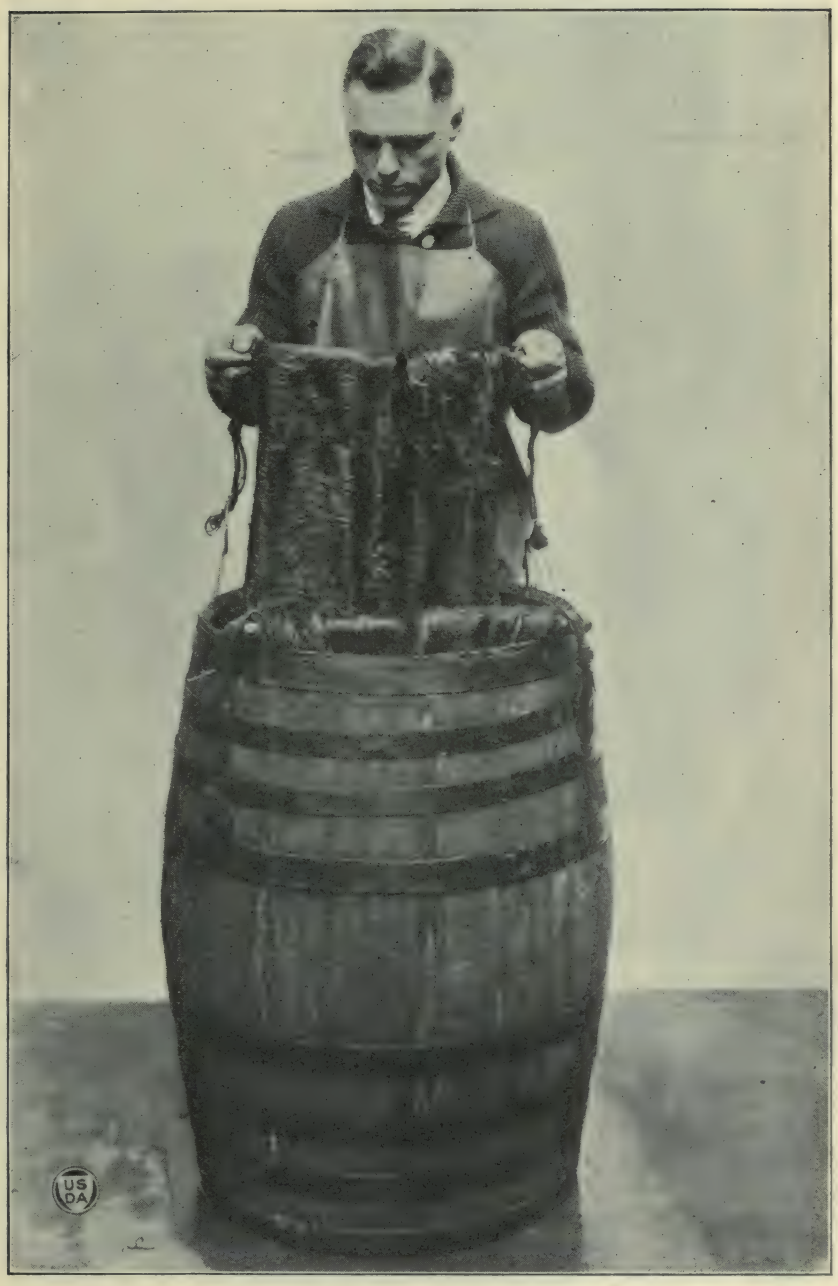

FIG. 2.—Putting a side into limewater.

The hide has been split into two sides, and soaked and cleaned. Each side is folded over a stick.

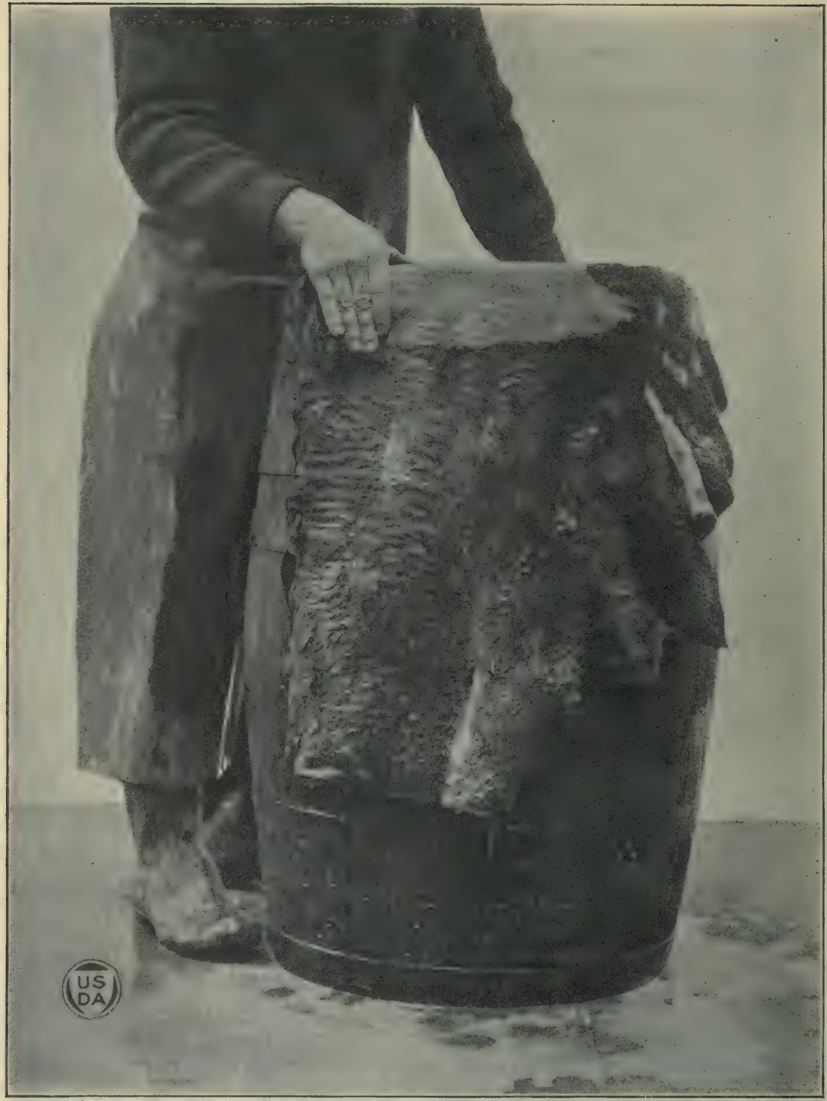

FIG. 3.—Ready to unhair after liming.

When the hair can be rubbed off easily with the hand the hide is ready to be unhaired.

hair will come off easily. This takes from 6 to 10 days in summer and possibly as many as 16 days in winter.

When thoroughly limed, the hair can be rubbed off readily with the hand. (Fig. 3.) Early in the liming process it will be possible to pull out the hair, but the hide must be left in the limewater until the hair comes off by rubbing over with the hand. For harness and belting leathers leave the hide in the limewater for from 3 to 5 days after this condition has been reached.

UNHAIRING.

When limed, throw the side, hair side up, over the beam, and, with the back edge of a drawing or butcher knife, held nearly flat against the side, push off the hair from all parts. (Fig. 4.) If the side is sufficiently limed, a curdy or cheesy layer of skin rubs off with the hair. If this layer does not rub off, the side must be returned to the limewater. After removing the hair, put the side back

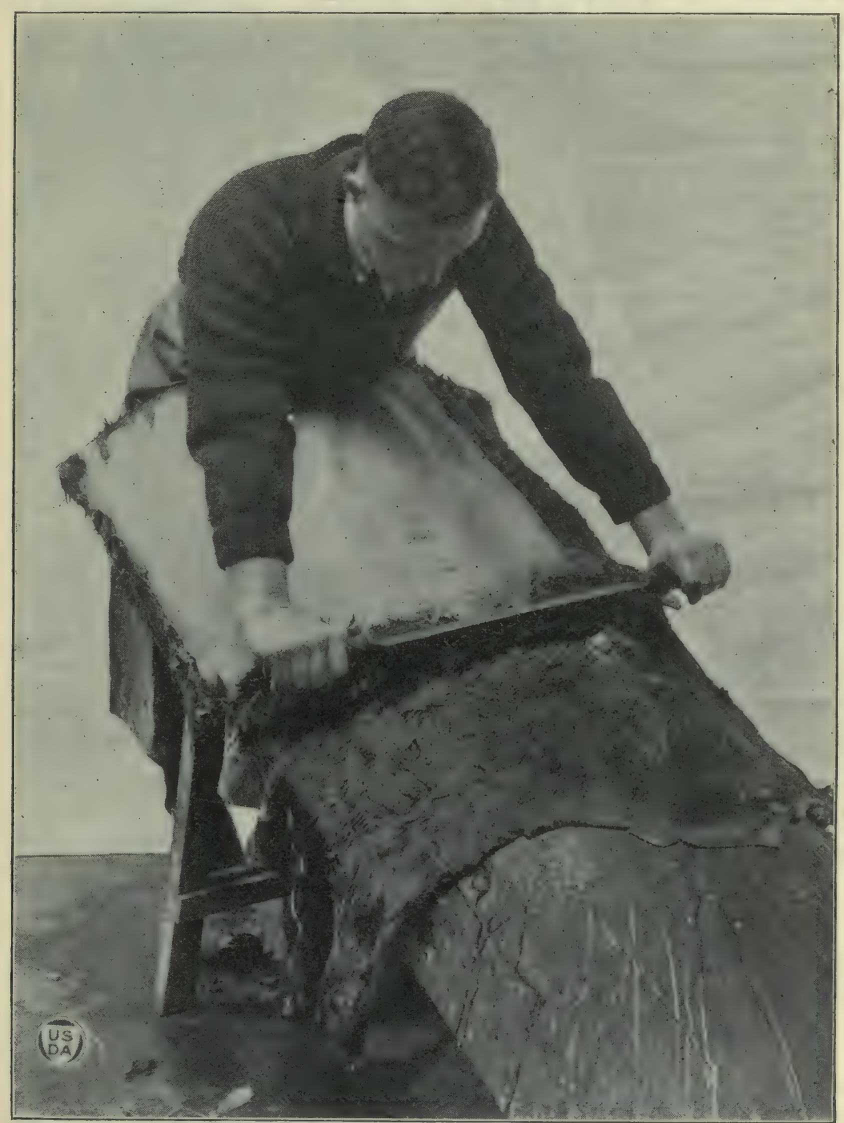

FIG. 4.—Unhairing.

After thorough liming, the hair is pushed or scraped off with a dull metal edge. At the same time some of the lime, grease, and dirt are worked out of the hide. Here the workman is using the dull edge of the fleshing knife and a tanner's beam.

in the limewater again for another day, until any fine hairs that may remain can be easily scraped off. Now thoroughly work over the grain or hair side with a dull-edged tool to "scud" or work out as much lime, grease, and dirt as possible.

FLESHING.

Turn the side over and "scud" it again, being sure to remove all fleshy matter. Shave down to the hide itself, but be careful not to cut into it. Remove the flesh by scraping and by using a very sharp knife (Fig. 1), with a motion like that of shaving the face (Fig. 5).

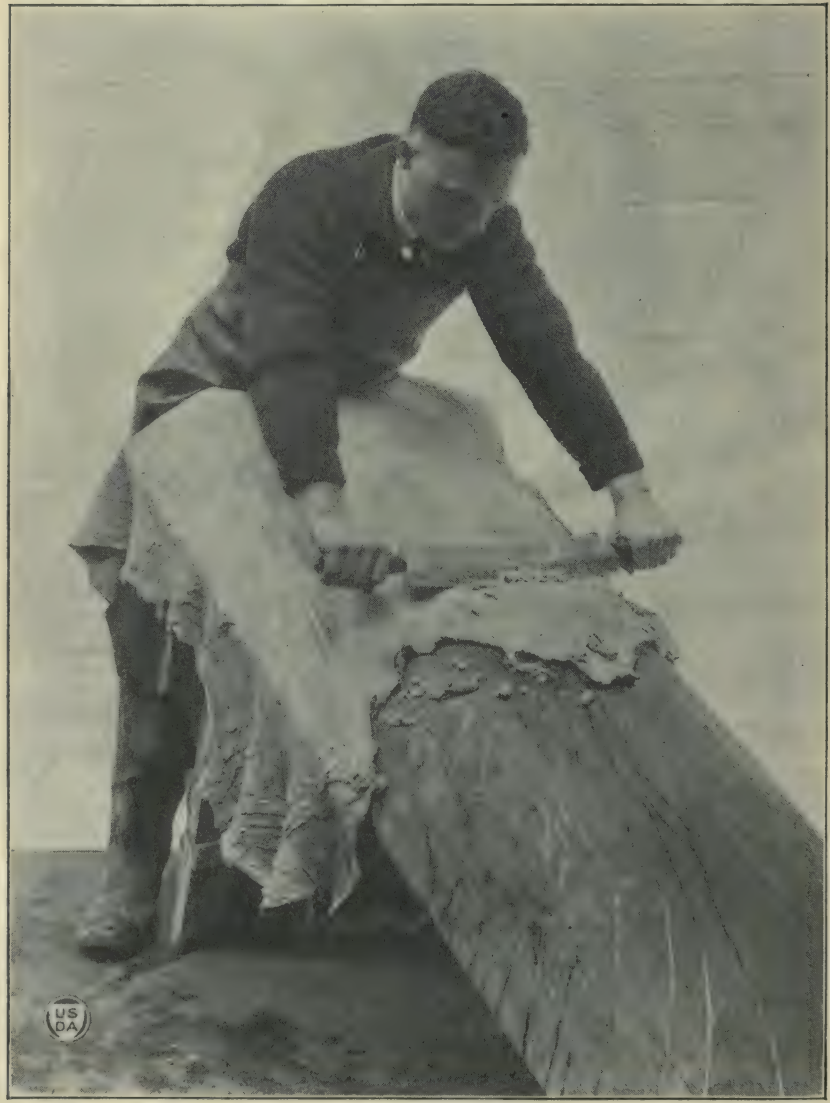

FIG. 5.—Fleshing.

All flesh, fat, and tissue must be shaved off down to the real hide or skin.

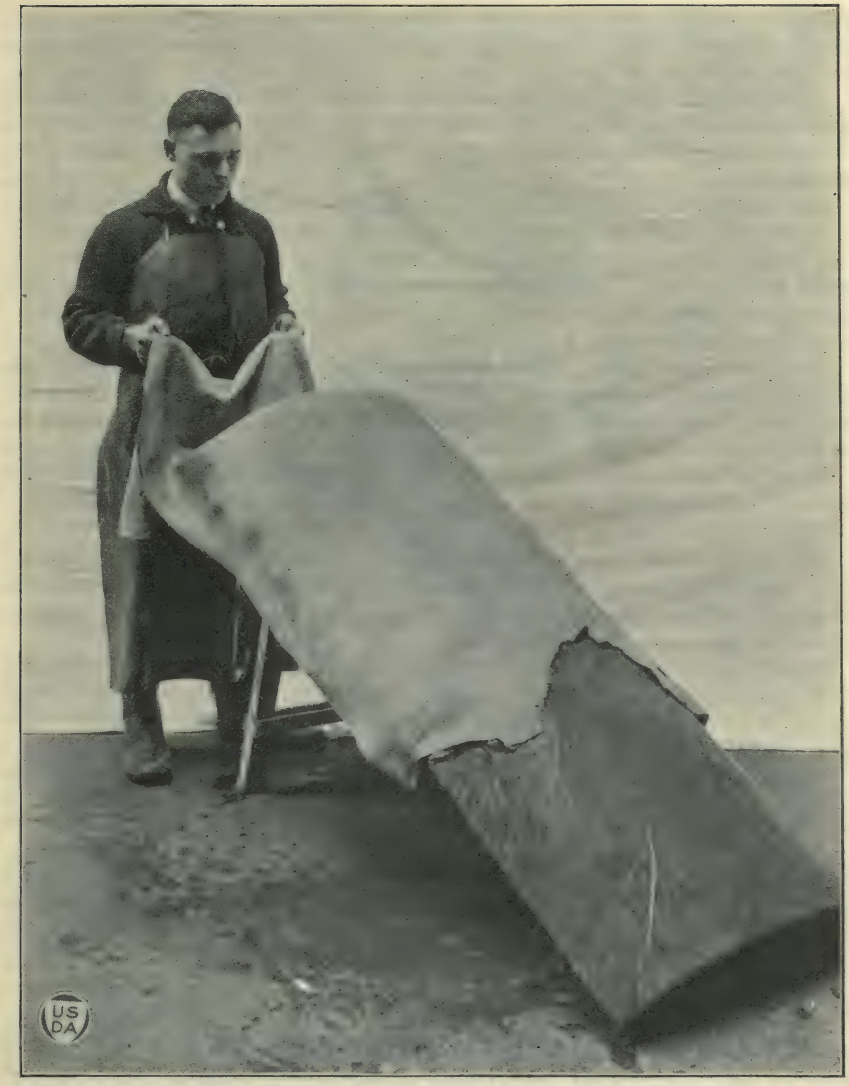

FIG. 6.—Unhaired, fleshed hide ready to be delimed.

All hair, flesh, and fat must be removed, as well as much of the lime and grease.

Now proceed as directed under "Bark-tanned sole and harness leather" (p. 12), "Chrome-tanned leather" (p. 15), or "Alum-tanned lace leather" (p. 20), depending upon the kind of leather desired.

WASTES FROM LIMING.

The lime, limewater, sludge, and fleshings from the liming process may be used as fertilizer, being particularly good for acid soils. The hair, as it is scraped from the hide, may be collected separately, and, after being rinsed several times, may be used in plastering. If desired, it can be thoroughly washed with many changes of water until absolutely clean and, after being dried out in a warm place, can be used for padding, upholstering, insulation of pipes, etc.

BARK-TANNED SOLE AND HARNESS LEATHER.

DELIMING.

After the sides have been put through the unhairing and fleshing operations, rinse them with clean water. Wash the sides in cool, clean water for from six to eight hours, changing the water frequently.

Buy 5 ounces of U. S. P. (United States Pharmacopœia) lactic acid (or 16 ounces of tannery 22 per cent lactic acid). Nearly fill a clean 40 to 50 gallon barrel with clean, cool water, and stir in the lactic acid, mixing thoroughly with a paddle. Hang the sides in the barrel and leave them there for 24 hours, pulling them up and stirring frequently.

Take out the sides, work over or "scud" them thoroughly, as directed under "Unhairing" (p. 9), and hang them in a barrel of cold water. Change the water several times, and finally leave them in the water overnight.

If lactic acid can not be obtained, use a gallon of vinegar instead.

TANNING.

The sides are now ready for the actual tanning. From 15 to 20 days before this stage will be reached weigh out from 30 to 40 pounds of good-quality, finely-ground oak or hemlock bark and pour onto it about 20 gallons of boiling water.

Finely-ground bark, with no particles larger than a grain of corn, will give the best results. Simply chopping the bark into coarse pieces will not do. Do not let the tan liquor come in contact with iron vessels. Use the purest water available. Rain water is best.

Let this bark infusion stand in a covered vessel until ready to use it. Stir it occasionally. When ready to start tanning, strain off the bark liquor through a clean, coarse sack into the tanning barrel. Fill the barrel about three-quarters full with water, rinsing the bark with this water so as to get out as much tannin as possible. Add 2 quarts of vinegar. Stir well. Place the sides, from the deliming, over sticks, and hang them in this bark liquor with as few folds and wrinkles as possible. Move the sides about and change their position often in order to get an even color.

Just as soon as the sides have been hung in the bark liquor, weigh out the same quantity of ground bark as before and soak it with hot water. Let this second bark liquor stand until the sides have become evenly colored, or for from 10 to 15 days. Take out of the tanning barrel 5 gallons of liquor and pour in about one-quarter of the second bark liquor. Also add about 2 quarts more of vinegar and stir it in well. Five days later add another fourth of the tan liquor only (no vinegar). Do this every 5 days until the second bark liquor is used up.

The progress of the tanning varies somewhat with conditions and can best be followed by inspecting a small sliver cut from the edge of the hide. About 35 days after the actual tanning has been started a fresh cut should show two dark or brown narrow streaks about as wide as a heavy pencil line coming in from each surface of the hide.

At this stage weigh out about 40 pounds of fine bark and just moisten it with hot water. Do not add more water than the bark will soak up. Pull the sides out of the bark liquor and dump in the moistened bark, keeping in the barrel as much of the old tan liquor as possible. Mix thoroughly and while mixing hang the sides back in the barrel. Actually bury them in the bark. All parts of the sides must be kept well down in the bark mixture. Leave the sides in this bark for about six weeks, moving them about once in a while.

At the end of six weeks pull the sides out. A cutting should show that the tanning has spread nearer to the center. Pour out about half the liquor. Stir the bark in the barrel, hang the sides back, and fill the barrel with fresh, finely ground bark. Leave the sides in for about two months, shaking the barrel from time to time and adding bark and water as needed to keep the sides completely covered.

At the end of this time the hide should be evenly colored all the way through, without any white or raw streak in the center of a cut edge. If it is not struck through, it must be left longer in the wet bark, and more bark may be needed.

For harness, strap, and belting leather the sides may be taken out of the bark liquor at this stage, but for sole leather they must be left for two months longer. When fully tanned through the sides are ready for oiling and finishing.

OILING AND FINISHING.

Harness and belting leather.—Take the sides from the tan liquor; rinse them off with water; and scour the grain or hair side thoroughly with plenty of warm water and a stiff brush. Then go over the sides with a "slicker" (Fig. 1), pressing the slicker firmly against the leather while pushing it away from the body. "Slick" out on the grain or hair side in all directions (Fig. 7). For harness, belting, and the like this scouring and slicking out must be thoroughly done.

A slicker can be made from a piece of copper or brass about one-fourth inch thick, 6 inches long, and 4 inches wide. One long edge of the slicker is mounted in a wooden handle and the other long edge is finished smooth and well rounded. A piece of hardwood, about 6 inches square, 1½ inches thick at the head, and shaved down wedge-shape to a thin edge, will also serve as a slicker. (Fig. 1.)

While the sides are still damp, but not very wet, go over the grain or hair side with a liberal coating of neat's-foot or cod oil. Hang up the sides and let them dry out slowly. When dry, take them down and dampen well by dipping in water or by rolling them up in wet sacking or burlap.

When uniformly damp and limber, evenly brush or mop over the grain or hair side a thick coating of warm dubbin. The dubbin is made by melting together about equal parts of cod oil and tallow or neat's-foot oil and tallow. This dubbin when cool must be soft and pasty, but not liquid.

Hang up the sides again and leave until thoroughly dried. When dry, scrape off the excess tallow by working over with the slicker. If more grease in the leather is desired, dampen again and apply another coating of the dubbin, giving a light application also to the flesh side. When again dry, remove the tallow and thoroughly work over all parts of the leather with the slicker. Rubbing over with sawdust will help to take up any surface oiliness.

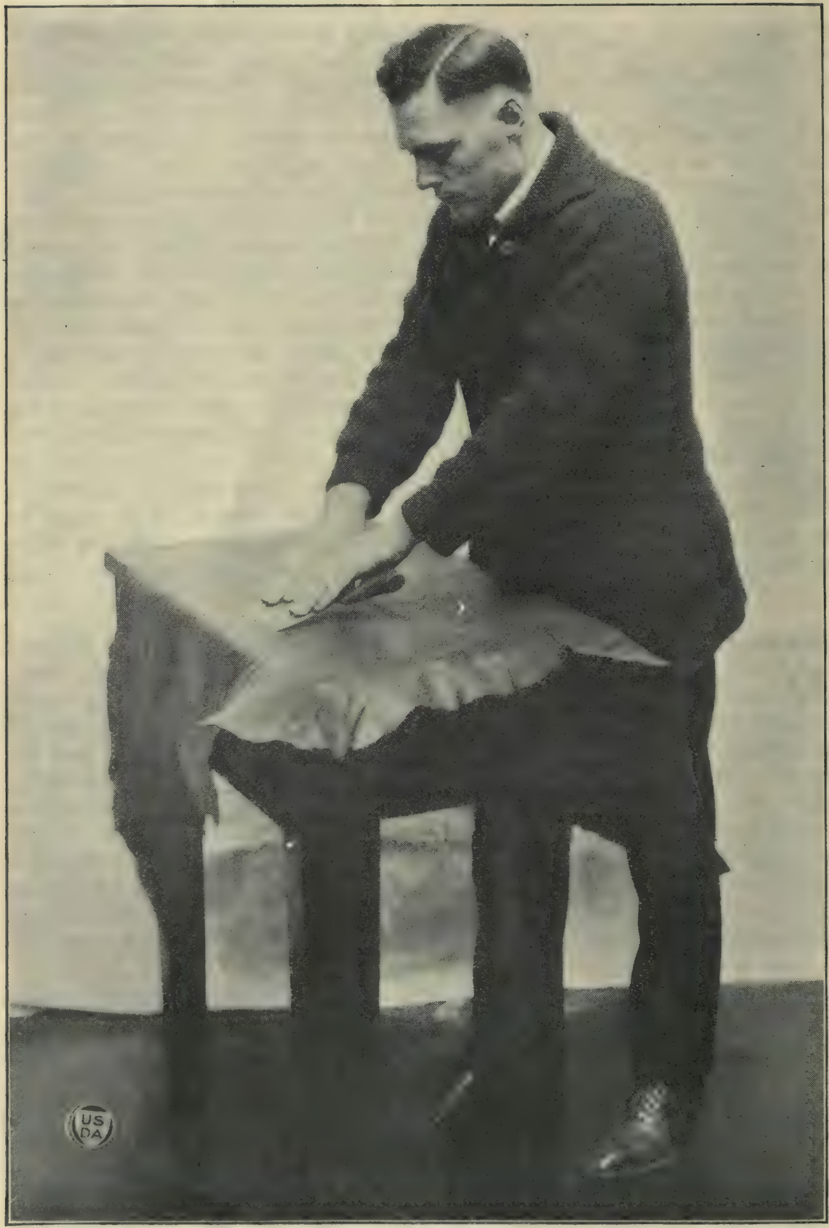

FIG. 7.—Slicking out.

After tanning and after greasing, the leather should be worked out on both sides with a slicker.

If it is desired to blacken the leather, this must be done before greasing. A black dye solution can be made by dissolving one-half ounce of water-soluble nigrosine in 1¼ pints of water, with the addition, if handy, of several drops of ammonia. Evenly mop or brush this solution over the dampened but ungreased leather and then grease as directed in the preceding paragraph.

Sole leather.—Take the sides from the tan liquor and rinse them thoroughly with clean water. Hang them up until they are only damp and then apply a good coating of neat's-foot or cod oil to the grain or hair side. Again hang them up until they are thoroughly dry.

When repairing shoes with this leather it is advisable, after cutting out the piece for soling, to dampen and hammer it down well, and then, after putting it on the shoe, to make it waterproof and more serviceable by setting the shoe in a shallow pan of melted grease or oil and letting it stand for about 15 minutes. The grease or oil must be no hotter than the hand can bear. Rubber heels should not be put in oil or grease. The soles of shoes with rubber heels may be waterproofed in the same way, using a pie pan for the oil or grease and placing the heels outside the pan. Any good oil or grease will do. The following formulas have been found satisfactory:

	Ounces.
Formula 1:	
Neutral wool grease	8
Dark petrolatum	4
Paraffin wax	4
Formula 2:	
Petrolatum	16
Beeswax	2
Formula 3:	
Petrolatum	8
Paraffin wax	4
Wool grease	4
Crude turpentine gum (gum thus)	2
Formula 4:	
Tallow	12
Cod oil	4

CHROME-TANNED LEATHER.

For many purposes chrome-tanned leather is considered to be as good as the more generally known bark or vegetable-tanned leather. The chrome process, which takes only a few weeks as against as many months for the bark-tanning process, derives its name from the use of chemicals containing chromium or "chrome." It is a chemical process requiring great care. It is felt, however, that by following exactly the directions here given, never disregarding details which may seem unimportant, a serviceable leather can be produced in a comparatively short time. The saving in time seems sufficient to justify a trial of this process.

DELIMING.

After the sides have been put through the unhairing and fleshing operations (p. 9) rinse them off with clean water.

If sole, belting, or harness leather is to be tanned, soak and wash the sides in cool water for about six hours before putting them into the lactic acid. Change the water four or five times.

If strap, upper, or thin leather is to be tanned, put the limed white sides into a wooden or fiber tub of clean, lukewarm (about 90° F.) water and let them stay there for from four to eight hours before putting them into the lactic acid. Stir the sides about occasionally. Be sure that the water is not too hot. It never should be so hot that it is uncomfortably warm to the hand.

For each large hide or skin buy 5 ounces of U. S. P. lactic acid (or 16 ounces of tannery 22 per cent lactic acid). Nearly fill a clean 40 to 50 gallon barrel with clean, cool water, and stir in the lactic acid, mixing thoroughly with a paddle. Hang the sides in the barrel, and leave them there for 24 hours, plunging them up and down occasionally.

For light skins, weighing less than 15 pounds, use only 2 ounces of U. S. P. lactic acid in about 20 gallons of water.

If lactic acid can not be obtained, use 1 pint of vinegar for every ounce of lactic acid. An effort should be made to get the lactic acid, however, for vinegar will not be as satisfactory, especially for the medium and smaller skins.

After deliming, work over both sides of the side as directed under "Unhairing" (p. 9).

For sole, belting, and harness leathers, hang the sides in a barrel of cool water overnight. Then proceed as directed under "Tanning."

For thin, softer leathers from small skins, do not soak the sides in water overnight. Simply rinse them off with water and proceed as directed under "Tanning."

TANNING.

The tanning solution should be made up at least two days before it is to be used—that is, not later than when the sides are taken from the limewater for the last time.

Remember that this is a chemical process and all materials must be of good quality and accurately weighed, and that the specified quantities of water must be carefully measured.

The following chemicals are required: Chrome alum (chromium potassium sulphate crystals); soda crystals (crystallized sodium carbonate); and common salt (sodium chlorid). Insist upon pure chemicals of United States Pharmacopœia quality. Get them from the nearest drug store or find out from it the address of a chemical manufacturing concern which can supply them.

For each hide or skin weighing more than 30 pounds use the following quantities for the stock chrome solution:

Dissolve 3½ pounds of soda crystals (crystallized sodium carbonate) and 6 pounds of common salt (sodium chlorid) in 3 gallons of warm, clean water in a wooden or fiber bucket. The soda crystals must be clear or glasslike. *Do not use the white crusted lumps.*

At the same time dissolve, in a large tub or half barrel, 12 pounds of chrome alum (chromium potassium sulphate crystals) in 9 gallons of cool, clean water. This will take some time to dissolve and will need frequent stirring. Here again it is important to use only the very dark, hard, glossy, purple or plum-colored crystals of chrome alum, not the lighter, crumbly, dull lavender ones.

When the chemicals are dissolved, which can be told by feeling around in the tubs with a paddle, pour the soda-salt solution slowly in a thin stream into the chrome-alum solution, stirring constantly. Take at least 10 minutes to pour in the soda solution. This should give one solution of about 12 gallons which is the *stock chrome solution.* Keep this solution well covered in a wooden or fiber bucket, tub, or half barrel.

To start tanning, pour one-third (4 gallons) of the stock chrome solution into a clean 50-gallon barrel and add about 30 gallons of clean, cool water; that is, fill the barrel about two-thirds full. Thoroughly mix the solution in the barrel and hang in it the sides from the deliming. Work the sides about and stir the solution frequently, especially the first two or three days. This helps to give the sides an even color. It should be done every hour or so throughout the first day. Keep the sides as smooth as possible.

After three days, temporarily remove the sides from the barrel. Add one-half of the remaining stock chrome solution, thoroughly mixing it with that in the barrel, and again hang in the sides. Move the sides about and stir the solution three or four times each day.

Three days later, once more temporarily remove the sides. Pour into the barrel the rest of the stock chrome solution, thoroughly mixing it with that in the barrel, and again hang in the sides. Move the sides about and stir frequently as before.

After the sides have been in this solution for three or four days, cut off a small piece of the thickest part of the side, usually in the neck, and examine the freshly cut edge of the piece. If the cut edge seems to be evenly colored greenish or bluish all the way through, the tanning is about finished. Boil the small piece in water for a few minutes. If it curls up and becomes hard or rubbery, the tanning is not completed and the sides must be left in the tanning solution for a few days longer, or until a small piece when boiled in water is changed little if at all.

The foregoing quantities and directions have been given for a medium or large hide. For smaller hides and skins the quantities of chemicals and water can be reduced. For each hide or skin weighing less than 30 pounds, or for two or three small skins together weighing not more than 30 pounds, the quantities of chemicals may be cut in half, giving the following solutions:

For the soda-salt solution, dissolve 1¾ pounds of soda crystals (crystallized sodium carbonate) and 3 pounds of common salt (sodium chlorid) in 1½ gallons of clean water.

For the chrome-alum solution, dissolve 6 pounds of chrome alum (chromium potassium sulphate crystals) in 4½ gallons of cool, clean water.

When the chemicals are dissolved pour the soda-salt solution slowly into the chrome-alum solution as already described. This will give one solution of about 6 gallons which is the *stock chrome solution.* For the lighter skins tan with this solution, exactly as directed for medium and large hides, adding one-third, that is, 2 gallons, of this stock chrome solution each time, and begin to tan in about 15 gallons instead of 30 gallons of water. Follow the directions already given as to stirring, number of days, and testing to determine when tanning is completed. Very small, thin skins probably will not take as long to tan as will the large hides. The boiling-water test is very reliable for showing when the hide is tanned.

WASHING AND NEUTRALIZING.

When the sides are tanned, take them out of the tanning solution and put them in a barrel of clean water. The barrel in which the tanning was done can be used after it has been thoroughly washed.

When emptying the tanning barrel be sure to carefully dispose of the tanning solution. Although not poisonous to the touch, it probably would be fatal to farm animals should they drink it, and it is harmful to the soil.

Wash the sides in about four changes of water. For medium and large hides, dissolve 2 pounds of borax in about 40 gallons of clean water and soak the sides in this solution overnight. For hides and skins weighing less than 25 pounds, use 1 pound of borax in about 20 gallons of water. Move the sides about in the borax solution as often as feasible. After soaking overnight in the borax solution, remove the sides and wash them for an entire day, changing the water five or six times. Take the sides out, let the water drain off, and proceed as directed under "Dyeing black," or, if it is not desired to blacken the leather, proceed as directed under "Oiling and finishing."

DYEING BLACK.

Water-soluble nigrosine.—One of the simplest and best means of dyeing leather black is the use of nigrosine. Make up the dye solution in the proportion of one-half ounce of water-soluble nigrosine dissolved in 1¼ pints of water. Be sure to get water-soluble nigrosine. Evenly mop or brush this solution over the damp leather after draining as already directed and then proceed as directed under "Oiling and finishing."

Iron liquor and sumac.—If water-soluble nigrosine can not be obtained, a fairly good black may be secured with iron liquor and sumac. To make the iron liquor, mix clean iron filings or turnings with one-half gallon of good vinegar and let the mixture stand for several days. See that there are always some undissolved filings or turnings in the vinegar. For a medium or large hide put from 10 to 15 pounds of dried crumbled sumac leaves in a barrel containing from 35 to 40 gallons of warm water. Stir well and when cool hang in it the wet, chrome-tanned sides. Leave the sides in this solution for about two days, pulling them up and mixing the solution frequently. Take out the sides, rinse off all bits of sumac, and evenly mop or brush over with the iron liquor. Rinse off the excess of iron liquor and put the sides back in the sumac overnight. If not black enough the next morning, mop over again with iron liquor, rinse, and return to the sumac solution for a day. Take the sides out of the sumac, rinse well, and scrub thoroughly with warm water. Finally wash the sides for a few hours in several changes of water.

While both of these formulas for dyeing have been given, it is recommended that water-soluble nigrosine be used whenever possible, as the iron liquor and sumac formula is somewhat troublesome and may produce a cracky grain. After blackening, proceed as directed under "Oiling and finishing."

OILING AND FINISHING.

Thin leather.—Let the wet tanned leather from the dyeing, or, if not dyed, from the neutralizing, dry out slowly. While it is still very damp go over the grain or hair side with a liberal coating of neat's-foot or cod oil. While still damp tack the sides out on a wall or tie them in frames (shown on cover), being sure to pull them out tight and smooth, and leave them until dry. When dry take down and dampen well by dipping in warm water or by rolling them up in wet sacking or burlap. When uniformly damp and limber go over the sides with a "slicker" (Fig. 1), pressing the slicker firmly against the leather, while pushing it away from the body. "Slick" out on the grain or hair side in all directions. (Fig. 7.)

After slicking it may be necessary to "stake" the leather (Fig. 8). This is done by pulling the damp leather vigorously back and forth

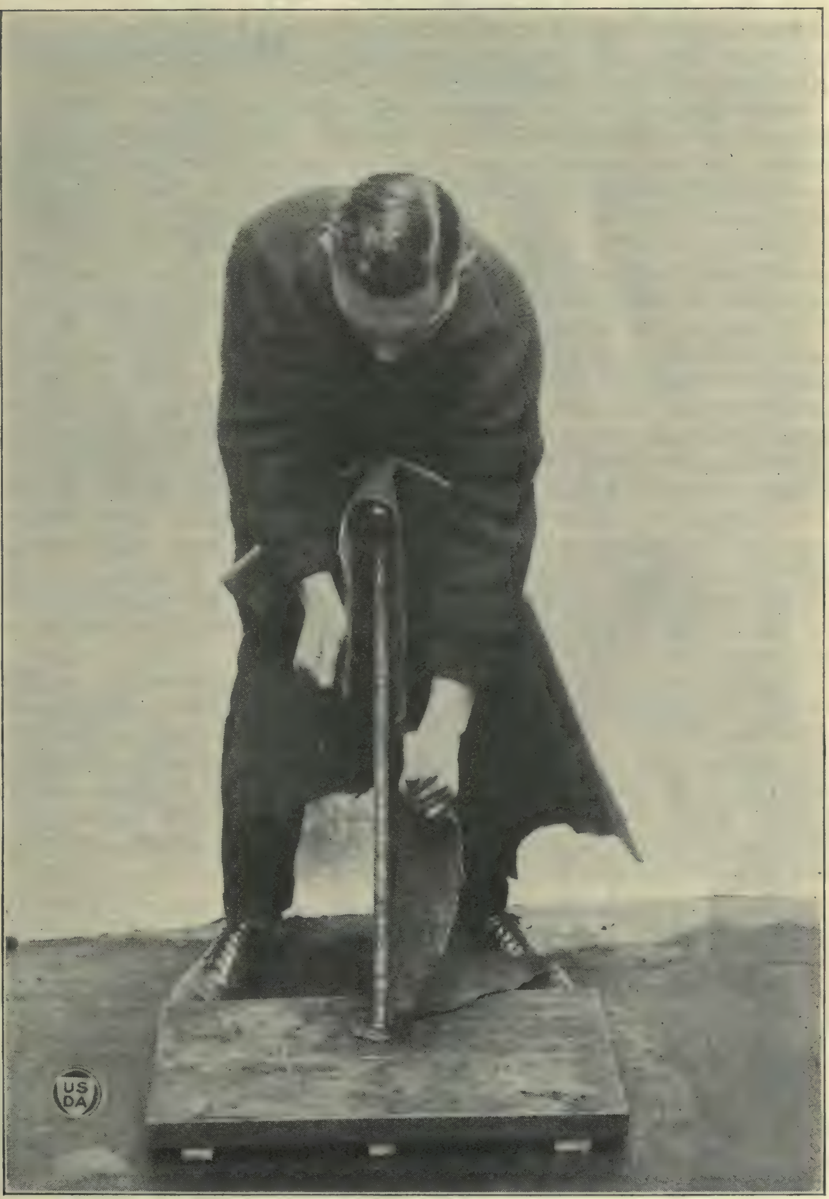

FIG. 8.—Staking.

To soften leather and tanned skins, they must be worked repeatedly back and forth in all directions over a dull edge. This must be done when the leather is drying.

over the edge of a small smooth board about 3 feet long, 6 inches wide, and 1 inch thick, fastened upright and braced to the floor or ground. The top end of the board must be shaved down to a wedge shape, with the edge not more than one-eighth inch thick and the corners well rounded (Fig. 1). Pull the sides, flesh side down, backward and forward over this edge, exactly as a cloth is worked back and forth in polishing shoes.

Let the sides dry out thoroughly again. If not sufficiently soft and pliable, dampen them with water, apply more oil, and slick and stake as before. The more time given to slicking and staking, the smoother and more pliable the leather will be.

Thick leather.—Thick leather from the larger hides is oiled and finished in a slightly different manner. For harness and strap leather, let the tanned sides, dyed if desired, dry down. While they are still quite damp slick over the grain or hair side thoroughly and apply a liberal coating of neat's-foot or cod oil. Tack on a wall or tie in a frame, stretching the leather out tight and smooth, and leave until dry. Take the sides down, dampen them with warm water until limber and pliable, and apply to the grain side a thick coating of warm dubbin. This dubbin is made by melting together about equal parts of cod oil and tallow or neat's-foot oil and tallow. When cool it must be soft and pasty, but not liquid. If too nearly liquid, add more tallow. Hang up the sides again and leave them until thoroughly dried. When dry, scrape off the excess tallow by working over with the slicker. If more grease in the leather is desired, dampen again and apply another coating of the dubbin. When again dry, slick off the tallow and thoroughly work over all parts of the leather with the slicker. Rubbing over with sawdust helps to take up surface oiliness.

Chrome-tanned leather is stretchy, so that in cutting the leather for use in harness, straps, reins, and similar articles it is best to first take out most of the stretch.

Chrome leather for shoe soles must be heavily greased, or, in other words, waterproofed, unless it is to be worn in extremely dry regions. Waterproofing may be done after repairing the shoes by setting them in a shallow pan of oil or grease so that just the soles are covered by the grease. The soles should be dry before they are set in the melted grease. Melted paraffin wax will do, although it makes the soles stiff. The simple formulas given on page 15 are satisfactory for waterproofing chrome sole leather.

ALUM-TANNED LACE LEATHER.

DELIMING.

After the sides have been put through the unhairing and fleshing operations (p. 9), rinse them off with cool, clean water for from six to eight hours, changing the water frequently.

Buy 5 ounces of U.S.P. lactic acid (or 16 ounces of tannery 22 per cent lactic acid). Nearly fill a clean 40 to 50 gallon barrel with clean, cool water and stir in the lactic acid, mixing thoroughly with a paddle. Hang the sides in the barrel and leave them there for 24 hours, pulling them up and stirring them about frequently. Take out the sides, work over or "scud" thoroughly, as directed under

"Unhairing" (p. 9), and hang them in a barrel of cool water. Change the water several times, and finally leave them in the water overnight.

If lactic acid can not be obtained, use a gallon of vinegar instead.

TANNING.

While the sides are being delimed, thoroughly wash out the barrel in which the hide was limed. Put in it 15 gallons of clean water and 12 pounds of ammonia alum or potash alum and stir frequently until it is completely dissolved.

Dissolve 3 pounds of washing soda (crystallized sodium carbonate) and 6 pounds of salt in 5 gallons of cold, clean water in a wooden bucket. The soda crystals must be clear and glasslike. *Do not use white crusted lumps.*

Pour the soda solution into the alum solution in the barrel very, very slowly, stirring the solution in the barrel constantly. Take at least 10 minutes to pour in the soda solution in a small stream. If the soda is poured in rapidly the solution will become milky and it will not tan. The solution should be cool, and enough water to nearly fill the barrel should be added.

Hang each well-washed side from the deliming in the alum-soda solution. Pull up the sides and stir the solution six or eight times each day. Do not put the bare hands in the liquor if they are cut or cracked or have sores on them.

After six or seven days remove the sides from the alum-soda solution and rinse well for about quarter of an hour in clean, cold water.

OILING AND FINISHING.

Let the sides drain and dry out slowly. While still very damp go over the grain or hair side with a liberal coating of neat's-foot or cod oil. After the oil has gone in and the sides have dried a little more, but are still slightly damp, begin to work them over a "stake." The time to start staking is important. The sides must not be too damp; neither must they be too dry. When light spots or light streaks appear on folding it is time to begin staking. Alum-tanned leather must be thoroughly and frequently staked.

Staking is done by pulling the damp leather vigorously back and forth over the edge of a small, smooth board (Fig. 1), as described on page 19. The sides must be staked thoroughly all over in order to make them pliable and soft, and the staking must be continued at intervals until the leather is dry.

When dry, evenly dampen the sides by dipping them in water or by leaving them overnight covered with wet burlap or sacks. Apply to the grain or hair side a thick coating of warm dubbin. This dubbin is made by melting together about equal parts of neat's-foot oil and tallow or cod oil and tallow. When cool, the dubbin must be soft and pasty but not liquid. If too nearly liquid, add more tallow. Leave the greased sides, preferably in a warm place, until dry. Scrape off the excess tallow and again stake the sides. If the leather is too hard and stiff, dampen it evenly with water before staking.

After staking, go over the sides with a "slicker" (Fig. 1), pressing the slicker firmly against the leather, while pushing it away from the body. Slick out on the grain or hair side in all directions. (Fig. 7.)

Alum-tanned leather almost invariably dries out the first time hard and stiff. It must be dampened again and restaked while drying. In some cases this must be done repeatedly and another application of dubbin may be necessary. By repeated dampening, staking, and slicking the leather can be made as soft and pliable as desired.

TANNING FUR SKINS.

Much of the value of a fur skin depends upon the manner in which it is handled in the raw state. After the animal has been caught, every effort should be made to follow the best practices in skinning and curing, in order to obtain a skin of the greatest possible value. Certain trade customs also must be followed to secure the top price. Detailed information on the manner of skinning and curing skins from the better-known fur-bearing animals is given in United States Department of Agriculture Yearbook Separate 823, Trapping on the Farm.[2]

Requests for directions for tanning fur skins are constantly received by the Department of Agriculture. There is, however, less need for such information than there is for information on farm or home tanning of hides and skins into leather. Fur skins as a protection are a necessity for those living in cold climates, but comparatively few are used for this purpose. Most of the fur skins are made into articles which are more or less of a luxury, and as such are valued largely by their appearance and finish which an inexperienced worker can seldom make sufficiently pleasing. Furthermore, raw fur skins are valuable, and, if well cared for, usually find a ready market. Nevertheless, the spread between the prices paid for raw furs and those demanded for finished fur articles is enormous. No doubt, this spread in many instances inspires the attempts at home manufacture.

An inexperienced person should not try to tan valuable fur skins or large hides, such as cattle, horse, or bear, for making into coats, robes, or rugs. The risk of damage or of an unsatisfactory product, as measured by the usual standards of finish and appearance, is too great. The difficulties in properly handling large hides make the chances of success remote, except by those having suitable equipment and experience. Moreover, tanning the skin is only one step in the production of the finished article. After being tanned, all skins must be tailored, many must be dyed, and small ones must be matched, blended, and sewed together. All these operations require experience and practice to secure the attractive appearance desired by wearers of furs. Some of the operations, such as those of bleaching and dyeing, are so highly specialized that their undertaking should not even be considered by an amateur. From the standpoint of serviceability and usefulness, inexperienced persons might meet with a fair degree of success in tanning and tailoring fur skins, but few can ever hope to make a fur piece or garment which will compare favorably in appearance with the shop or factory product.

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[2] A copy of this separate may be obtained upon request to the Division of Publications, United States Department of Agriculture, Washington, D. C. A list of other publications by the Bureau of Biological Survey, U. S. Department of Agriculture, giving detailed information on the raising, trapping, and utilization of certain fur-bearing animals will be found on page 28 of this bulletin.

The tanning and dressing of fur skins, then, are best left to those who are experienced and equipped to carry out the tedious operations required. A list of fur dressers who will tan skins for an individual, working them up into the desired finished article, will be supplied by the Department of Agriculture upon request.

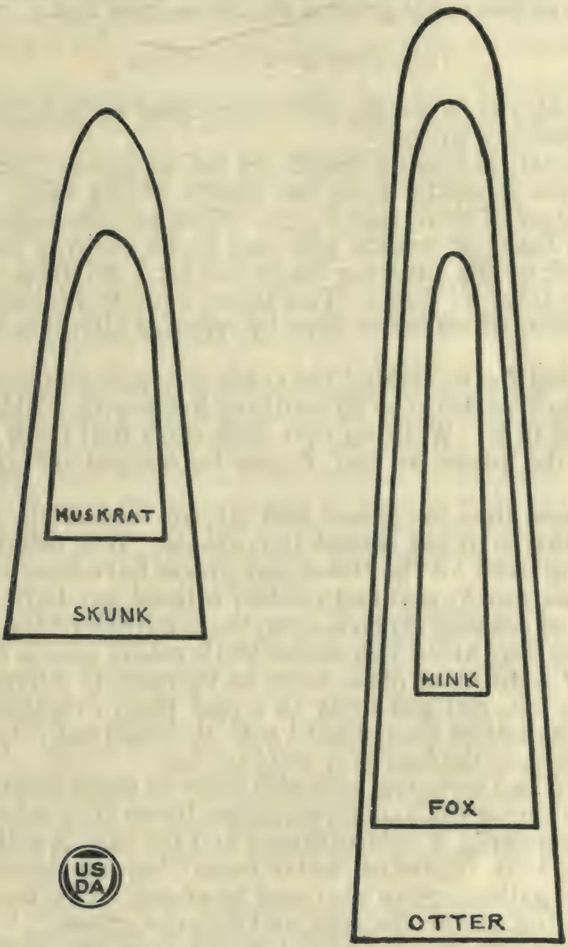

FIG. 9.—Stretching boards for fur skins.

Cased fur skins are dried on boards of different sizes and shapes, depending upon the kind of skin.

To satisfy the demand upon the department for information on the home tanning of fur skins and to provide those who insist upon carrying on such work with correct information and with detailed methods which offer the best chances for success, the following directions are given. These directions are meant primarily for small fur skins no larger than that of the fox and for skins of low market value.

No formulas for tanning are foolproof and success can be attained only by close observation, plenty of work, and the exercise of care and patience. All skins are not treated just alike. In fact, each skin has its own peculiarities, which only experience can show how to treat. Some skins are tough and fairly thick and will stand mistreatment; others are very thin and tender and are easily ruined. Some are fat and greasy and require thorough working out of the grease; others do not. An inexperienced person should experiment with the least valuable skins. If a number of skins of the same kind are to be tanned, one or two of the poorest should be tried first.

SOAKING AND FLESHING.

The first step is to get the skin thoroughly softened, cleaned, and free from flesh and grease.

Split the tail the entire length on the underside. If the skin is "cased," split it neatly down the middle of the belly. Soak it in several changes of clear, cool water. When the skin begins to soften, lay it on a beam or smooth pole and begin working over the flesh side to break up the adhering tissue and fat. All dried skins have a shiny, tight layer of tissue. This tissue must be broken up and entirely removed, which is best done by repeated alternate working and soaking.

A good tool for scratching the tissue is a metal edge of any kind, such as a drawing knife or an ordinary knife with dull saw teeth or notches filed in it. Working over with these dull teeth scratches or breaks up the tissue so that it can be scraped off after further soaking.

At the same time the grease and oil are worked out of the skin. This operation is of the utmost importance. It is utterly useless to start tanning until all the tissue and grease have been removed and the skin is uniformly soft and pliable, without any hard spots.

The time of soaking depends upon the condition of the skin. Some skins require only about two hours, while others need a much longer time. Very hard skins often must be thoroughly dampened, rolled up, fur side out, and put away in a cool place overnight to soften. While a skin must be soaked until soft, it should not stay wet longer than necessary, as the hair may start to slip.

In fleshing and scraping, care also must be taken not to injure the true skin or expose the hair roots, especially on thin skins.

When the soaking is well advanced and the skin is getting in good shape, work it in lukewarm water containing an ounce of soda or borax to the gallon. Soap also may be added. This treatment promotes softening, cleans the skin, and cuts the grease.

Work again over the beam and finally rinse thoroughly in lukewarm water. Squeeze out most of the water, but do not wring the skin. Without further drying, work the skin in gasoline, using several changes if very much dirt and grease are present. Squeeze and hang up the skin for a few minutes.

The skin should now be ready for tanning. When painting or pasting of the tan liquor on the flesh side only is included in the directions for tanning, it is best to dry out the hair or fur side first by working in sawdust. In this way any heating of the fur side while the skin is tacked out is avoided, as are also matting and stiffening of the fur. If while drying out the fur, the flesh side becomes too dry, it must be evenly dampened with a wet cloth before applying the tan liquor.

COMBINATION TANNAGE.

A combination tannage is a combination of mineral and vegetable tanning. It has an advantage over the salt-acid or salt-alum processes in giving a soft and flexible skin, as well as a more lasting tannage.

One of the most popular and successful formulas for a combination tannage is given by M. C. Lamb.[3] A pasty mixture of alum, salt, gambier, and flour, with or without glycerin or olive oil, is made as follows: Dissolve 1 pound of aluminium sulphate and 1 pound of salt together in a small quantity of water. Dissolve 3 ounces of gambier or Terra Japonica in a little boiling water. Mix the two solutions and make up to 2 gallons with water. As this solution is used, mix it with enough flour to make a moderately thin paste. If the skin has a hard texture and lacks natural grease, thoroughly mix a little olive oil or glycerin with the paste.

Soak, soften, and clean the skin as previously described and tack it out flat and smooth, flesh side up. Apply from two to three coatings of the paste, depending upon the thickness of the skin. Only thick skins require three coatings. Each coating should be about one-eighth inch thick and should be applied at intervals of a day. Between applications the skin should be kept covered with sacking or paper. Scrape off most of the old coating before putting on a new one. After the last coating has been applied, spread out the skin uncovered or hang it up to dry slowly.

When practically dry, wash off the flour paste, rinse for several minutes in water containing an ounce of borax to the gallon, then in water alone. Squeeze out most of the water. Put the skin over a beam and slick it out well on the flesh side with the back of a knife or edge of a wooden slicker (Fig. 1), thus working out most of the water (Fig. 7). Again tack the skin out smoothly, flesh side up, and apply a thin coating of any animal fat, fresh butter being particularly good, or a nondrying oil, such as neat's-foot, castor, or olive oil. Glycerin or a soap may be used instead of the grease or oil. If the skin originally was very greasy, it may not be necessary to apply any oil.

When nearly dry, but still slightly damp, begin to work the skin in all directions, stretching it from corner to corner and working the flesh side over a stake (Fig. 1) or a wooden edge, such as the back of a chair or piece of board clamped in a vise.

The time to begin working is important and is best judged from experience. The skin must not be too wet; neither must it be too dry. The appearance of a few light spots or a light streak on folding is a good indication of the time to start working the skin.

Work the skin in all directions back and forth, as if shining shoes with a cloth. The skin may also be worked this way through smooth metal rings. Much of the success in getting a soft skin lies in this repeated working, which must be done *while the skin is drying out, not after it is dry.* If the skin is not soft enough when dry, it must be evenly dampened and worked again while drying. This may be repeated several times if necessary.

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[3] **Leather Trades Review, Aug. 20, 1913, p. 596.**

After softening and drying out it is well to give the skin a hasty bath in gasoline. If the skin is greasy, this must be done. This also helps to deodorize some skins, such as those of the skunk.

Finally, to clean and brighten the tanned skin, tumble or work it repeatedly in dry, warm sawdust, preferably hardwood sawdust, or bran or cornmeal. Clean these out of the fur by gentle shaking, beating, combing, and brushing.

The flesh side may be smoothed if necessary by working over a sandpaper block. This also helps to further soften the skin. If desired, the thicker sections of the skin may be made thinner and more flexible by shaving off some of the skin or hide.

SALT-ALUM TANNAGE.

The salt-alum process, an old method for fur-skin tanning, is widely used. It is considered slightly better than the salt-acid tannage, being a little more permanent and, when properly carried out, giving skins which have a little more stretch and flexibility. It often happens, however, that alum-tanned skins come out stiff and hard and must be repeatedly worked and sometimes retanned.

A salt-alum tanning solution may be made up in the following proportions: 1 pound of ammonia alum or potash alum, dissolved in 1 gallon of water; 4 ounces of washing soda (crystallized sodium carbonate) and 8 ounces of salt, dissolved together in one-half gallon of water. When dissolved, pour the soda-salt solution very slowly into the alum solution while stirring vigorously.

The skin, cleaned and softened as previously described, may be tanned by immersion in this solution for from two to five days, depending upon its thickness. Because of the action of alum on some furs it may be best, as a general rule, to apply the tanning liquor as a paste to the flesh side only.

Mix the tan liquor as used with sufficient flour to make a thin paste. Add the flour in small quantities, with a little water, and mix thoroughly to avoid lumps. Tack the skin out smoothly, flesh side up. Apply a coating of the paste about one-eighth inch thick and cover the skin. The next day scrape off most of the paste and give another coating. Apply altogether, at intervals of a day, from two to three coatings, depending upon the thickness of the skin. Only thick skins should need as many as three treatments. Leave the last coating on for three or four days. Finally scrape off and rinse clean in water, putting in about an ounce of borax to the gallon of water. Rinse at last in water only.

Work over the beam to remove most of the water. Stretch the skin out flat and sponge over the flesh side with a thin soap paste. After this has gone in, apply a thin coating of oil. Leave the skin stretched out to dry, and while it is still damp, work and stake as described on page 25, wetting and working repeatedly if necessary. Finally, clean in gasoline and sawdust and finish as described above.

SALT-ACID TANNAGE.

One of the oldest processes of tanning requires various mixtures of common salt and sulphuric acid. Tanning, or, more correctly speaking, tawing, by this means is open to the objection that sulphuric acid must be used very cautiously, and must be completely neutralized to prevent later damage to the skin. Skins tanned with salt and acid also show a tendency to become damp and clammy in wet weather and, if repeatedly subjected to wetting, lose their tanned effect.

A salt-acid tanning solution may be made up in the following proportions: For each gallon of water use 1 pound of common salt and one-half ounce of concentrated sulphuric acid. Dissolve the salt and carefully pour in the acid with stirring. This tan liquor must be made and used in jars or wooden vessels, *never in metal containers of any kind.* (When pouring in the acid, do not inhale any more of the fumes given off than is necessary, and also be careful not to get any of the strong acid on the skin or clothing.) As soon as the acid-salt solution has cooled, it is ready for use.

Put the cleaned, softened skin in the solution so that it is entirely covered and leave it for from one to three days, depending upon its thickness. During this time stir the skin about frequently. If desired, the solution may be painted on instead. In this case, tack out the skin smoothly, flesh side up, paint over with the solution, and cover the skin with well-dampened sacking or cloth. At the end of six hours, paint over it again. With thicker skins, give one or two more applications of the solution about six hours apart, keeping the skin covered between applications. After the last application, hang up the skin or spread it, flesh side up, without cover, and let it dry.

After tanning, either by immersion or by painting, rinse the skin in clear water and squeeze out most of the water, but do not wring it. Then work the skin for about 10 minutes in a solution made up in the proportion of an ounce of borax in a gallon of water, and finally rinse well in clear water and squeeze.

Work over the skin with a slicker (Fig. 1) to remove most of the water, tack it out flat, flesh side up, and apply a thin coating of grease or oil. Leave the skin stretched to dry, and while still damp work and stake as described on page 25.

Finally clean in gasoline and sawdust, and finish by shaking, beating, sandpapering, brushing, and combing.

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U. S. DEPARTMENT OF AGRICULTURE
FARMERS' BULLETIN No. 1335

CONTROLLING *the* GIPSY MOTH *and the* BROWN-TAIL MOTH

1862 1889

THE gipsy moth and the brown-tail moth are two very destructive enemies of tree foliage that were accidentally introduced into this country from Europe. Both have spread over a large part of New England, the gipsy moth now occupying about one-half and the brown-tail moth about one-third of that region. The gipsy moth has been found in one large area in New Jersey, but has been effectively controlled. Scattered colonies of this insect found in adjoining States from time to time have nearly all been exterminated. The area infested by the gipsy moth has increased, but the brown-tail moth at present occupies a smaller area than in 1914.

The Federal Government and the States concerned are cooperating in an unremitting warfare against these two insects. A Federal quarantine prevents the shipment out of the infested territory of products liable to infestation, except after strict inspection, under regulations made by the Federal Horticultural Board. The States and the Federal Government, the latter acting through the Bureau of Entomology, are both actively engaged in destroying these insects by the use of appropriate control measures. The Federal Government is chiefly concerned in preventing their spread, while the States aim to reduce their numbers and prevent the defoliation of valuable trees in woodlands, orchards, and parks.

The means which have been found effective in destroying the insects are set forth in this bulletin, followed by an account of the work which the Federal Government and the States are doing.

Washington, D. C. **July, 1923**

CONTROLLING THE GIPSY MOTH AND THE BROWN-TAIL MOTH.[1]

A. F. BURGESS,
Entomologist in Charge of Gipsy Moth and Brown-Tail Moth Investigations, Bureau of Entomology.

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INTRODUCTION AND SPREAD.

IN 1869 a number of egg clusters of the gipsy moth,[2] a very destructive insect pest in Europe, were brought from France to Medford, Mass., by an astronomer who had the fanciful idea that he could cross these insects with silkworms. Later in the season some of the caterpillars escaped, and although none was found in the vicinity during the next few years, enough specimens survived to enable the species to establish itself. In the summer of 1889 this insect became so abundant that fruit and shade trees in the neighborhood were completely defoliated, and the caterpillars swarmed over the trees and into the houses and became a serious nuisance. This resulted in the loss of valuable trees and in the depreciation of property values in that section.

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[1] This bulletin is a revision of and supersedes Farmers' Bulletin 845, The Gipsy Moth and the Brown-tail Moth and Their Control.

[2] *Porthetria dispar* L.

For about 10 years effective work against the gipsy moth was carried on by the State of Massachusetts, and during this period the insect was kept under control. The work was discontinued in 1900, but by 1905 the species had become so abundant and had caused such widespread injury that systematic work was renewed by the State in order to protect the tree growth in the infested area. This work has been continued up to the present time. As the insect spread to other New England States it became necessary to institute more extensive control measures.

In 1906, after the gipsy moth had become established in New Hampshire and Rhode Island, as well as in Massachusetts, an appropriation was made by Congress for suppressing it, and the Secretary of Agriculture was authorized to take all possible measures to prevent its spread. Since that time work has been carried on each year. The area in New England now known to be infested is shown on the accompanying map (Fig. 1).

In 1912 a small area was found heavily infested with the gipsy moth at Geneva, N. Y. Prompt action was taken by the State department of agriculture, and the Bureau of Entomology of the United States Department of Agriculture cooperated. The area was thoroughly scouted as well as a large belt of contiguous territory. Several very thorough examinations have been made since then, but no trace of the insect has been discovered.

In February, 1914, a small colony was discovered at Bratenahl, near Cleveland, Ohio. Immediate attention was given to this colony in cooperation with the Ohio Department of Agriculture. Very thorough inspection and treatment work was required for three seasons before the colony was exterminated.

In May, 1914, a colony was found by State inspectors in North Castle, Westchester County, N. Y. The infestation was heavy at the center, and scouting determined that it extended over about 1 square mile. Intensive work was done throughout this area and the surroundings, and although the locality was a very difficult one to treat thoroughly the area was cleared of the moth.

In July, 1914, a small colony was found at Rutherford, N. J., but this was exterminated.

August 20, 1912, Congress passed a law creating the Federal Horticultural Board, which was authorized to make regulations relative to the importation of plants and plant products from foreign countries and to administer foreign and domestic quarantines as a protection from injurious insect pests and plant diseases. This board requires the inspection and certification of all living plants before importation to this country, and by a system of permits and notification respecting the movement of such stock it is possible for the State inspectors to inspect it at destination.

Early in July, 1920, the gipsy moth was found on a large estate near Somerville, N. J., by one of the State inspectors. The infestation centered in a large plantation of blue spruce trees, several acres of which were defoliated. Some dead trees in the worst infested portion indicated that they had been killed as a result of defoliation and that the infestation was one of long standing.

Inquiry showed that these trees had been imported from Holland 10 years before, and there is no doubt that the infestation came with the shipment, which was received before the passage of the law creating the Federal Horticultural Board. This shows clearly the pressing need for precautionary measures to keep out dangerous pests.

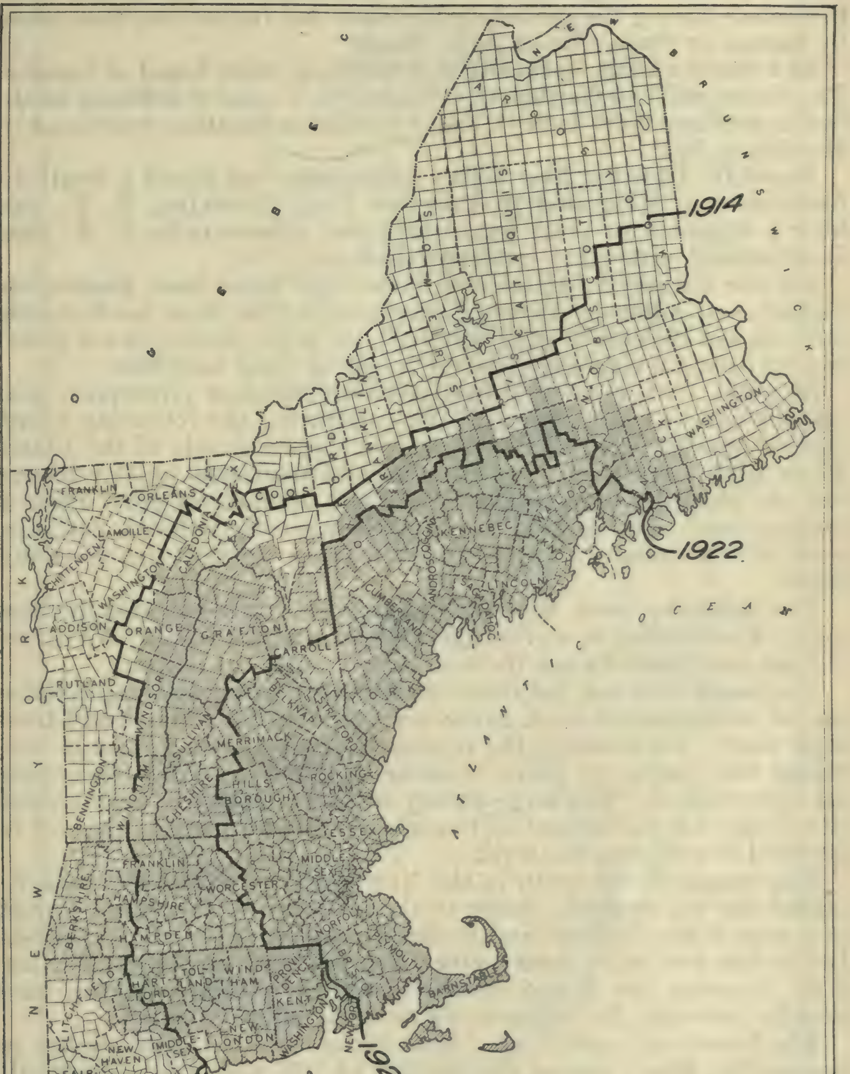

FIG. 1.—Map of New England. The shaded area is infested by and quarantined for the gipsy moth; the area between the line marked 1914 and the ocean and that between the line marked 1922 and the ocean were infested with and quarantined for the brown-tail moth in those years.

Scouting work carried on during the winter and spring was financed by the State of New Jersey and by the Federal Government, and the insect was found at scattered points in an area of over 400 square miles. (Fig. 2.) In addition to this, it was necessary to trace several hundred shipments of trees that had been forwarded from this estate during the preceding 10 years, and inspections were made by bureau or State officials in 17 States.

As a result of this work, slight infestations were found at Loretto, Pa.; Garrison, Kew Garden, and Roslyn, N. Y.; and 8 different localities in northern New Jersey. Later another infestation was found in Mendham, N. J.

About the time the New Jersey infestation was found a small infestation was discovered in Prospect Park, Brooklyn, N. Y., and later a shipment of posts was found near Schenectady, N. Y., that were infested with gipsy-moth egg clusters.

All the scattered infestations mentioned have been thoroughly treated, and although repeated inspections have been made in the colonies and the surrounding territory, the gipsy moth was not found in 1922 except a single egg cluster in one of these localities.

In June, 1921, a small infestation was found at Greenport, near the east end of Long Island, N. Y., and during the following month another was reported at Patchogue, on the south side of the island. These have since been given very careful treatment by this bureau and the State Department of Farms and Markets of New York in cooperation.[3] The infestations have been greatly reduced, but more work will be necessary before these areas are entirely free from this insect.

The intensive work done in the extensive infested area in New Jersey has resulted in an enormous decrease of the insect. No injury to trees has resulted since the eradication work was begun.

The result thus far has demonstrated that small outlying colonies can be exterminated when funds are available for prompt and thorough work. Of necessity the treatment and rescouting must be continued for a series of years, to make sure that no infestations have been overlooked. The large colony in New Jersey has been treated effectively, but on account of the area involved a longer time will be required to complete the work.

The spread of the moth in the New England States has been retarded but not stopped, owing to the necessity of carrying on work in a most difficult region and to inadequate funds at critical periods. In the last few years these factors, together with conditions particularly favoring the spread of the insect by natural agencies, have greatly increased the difficulty of securing effective results.

The brown-tail moth[4] was first found in the United States in Somerville, Mass., during the summer of 1897 and was undoubtedly introduced several seasons previous to that time on imported nursery stock. The work of preventing damage by this insect was undertaken by the State of Massachusetts soon after the pest was discovered. This species occurs in many sections of Europe and is often seriously injurious. It spreads rapidly because the females are able to fly long distances. Suppressive measures by the New England States and by the Federal Government have been directed against this insect as well as against the gipsy moth.

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[3] In March, 1923, the gipsy-moth work was transferred to the Department of Conservation.

[4] *Euproctis chrysorrhoea* L.

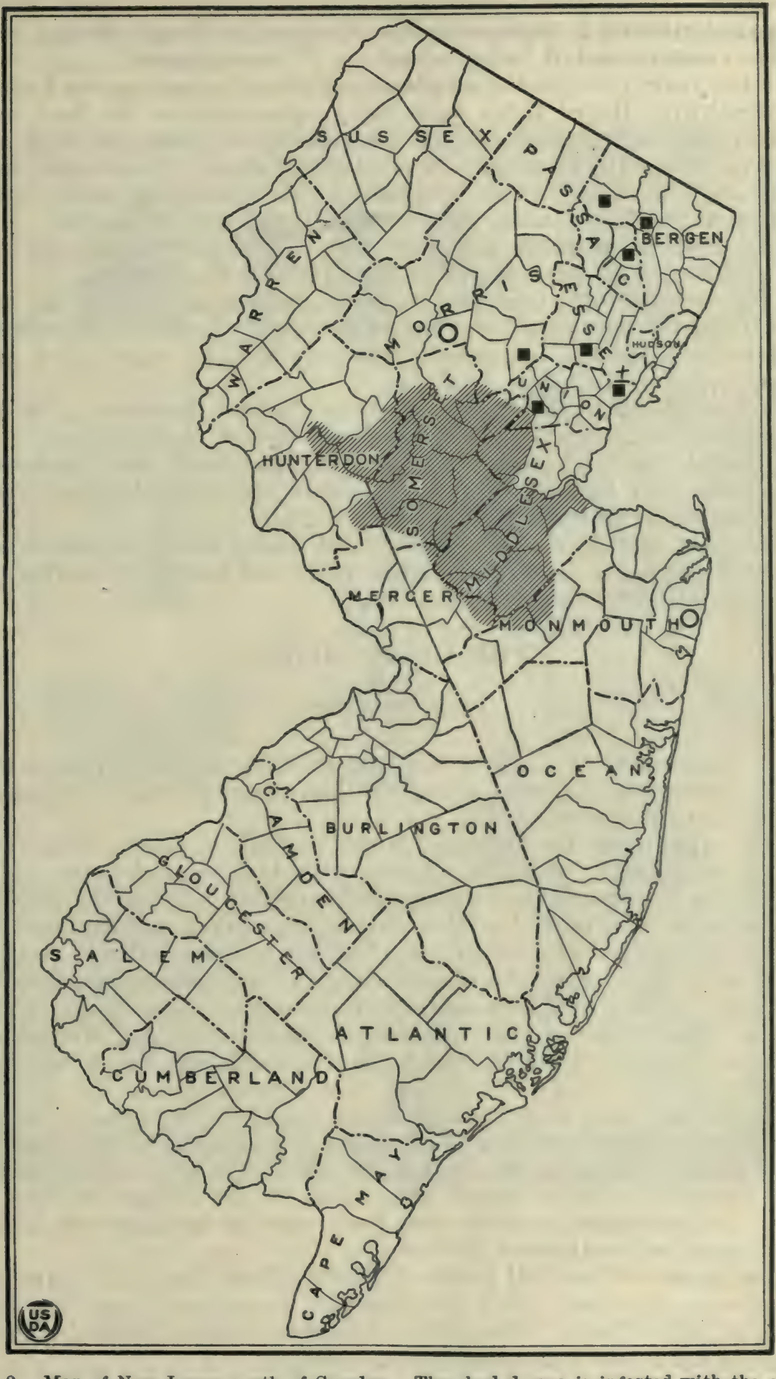


FIG. 2.—Map of New Jersey north of Camden. The shaded area is infested with the gipsy moth; the black squares are areas that were infested and have been cleared of the moth; the circles are areas that are still slightly infested.

Figure 1 shows the dispersion of this insect in the United States. The area infested is confined to New England, although several years ago the eastern end of Long Island, N. Y., was infested.

In the years prior to the enactment of the law creating the Federal Horticultural Board there were many opportunities for this insect to become widely established in this country by means of webs containing caterpillars brought in on nursery stock. Since such stock must now be inspected as a condition of permitting entry, many winter webs of this insect have been collected and destroyed.

The insect is established in Nova Scotia, and a few years ago scattered infestations were found in New Brunswick, Canada.

The map indicates the area in the United States infested in 1914, which was the maximum, and the territory now known to be infested. The reasons for the improved conditions will be stated in a later paragraph.

No brown-tail moths have been found in New Brunswick for several years and only small local infestations in Nova Scotia.

The methods used in suppressing the gipsy moth and the brown-tail moth have proved efficient, and they are given for the benefit of those who require this information for use.

Facts concerning the life history and habits of these insects have been obtained as a result of detailed study and extensive experiments conducted through a period of years.

THE GIPSY MOTH.

LIFE HISTORY.

In the course of its life the gipsy moth passes through four stages—the egg, the larva or caterpillar, the pupa or resting stage, and the adult or moth. (Fig. 3.)

The eggs.—The female gipsy moth deposits a cluster containing 400 eggs or more, which she covers with buff-colored hairs. Most of the egg clusters are laid during July and hatch about the time the leaves begin to appear the following spring. They are deposited on the under side of branches of trees, on tree trunks, under loose bark, or in cavities in the trunks or branches, and are sometimes placed on stones or rubbish and in a variety of situations where they are concealed from view. As the female moth does not fly, egg clusters are seldom found far from the food plant upon which the caterpillars developed.

The larvæ.—The newly hatched larvæ feed on the opening leaves, making small perforations. They grow rapidly and become full fed early in July. During this period they molt five or six times, and as they increase in size a larger proportion of the foliage is eaten, so that if the infestation is severe, trees may be stripped of foliage completely before the end of June.

The pupæ.—When full grown the caterpillars shed their skins and transform to pupæ, which are chestnut brown and provided with tufts of yellow hairs. They remain in this dormant stage for about 10 days, after which the adult insects emerge.

The adults.—The male moth is dark brown, with black wing markings, and flies well. The female is white, with black markings on the wings, and because of the weight of the abdomen does not fly. After mating, the females begin depositing eggs.

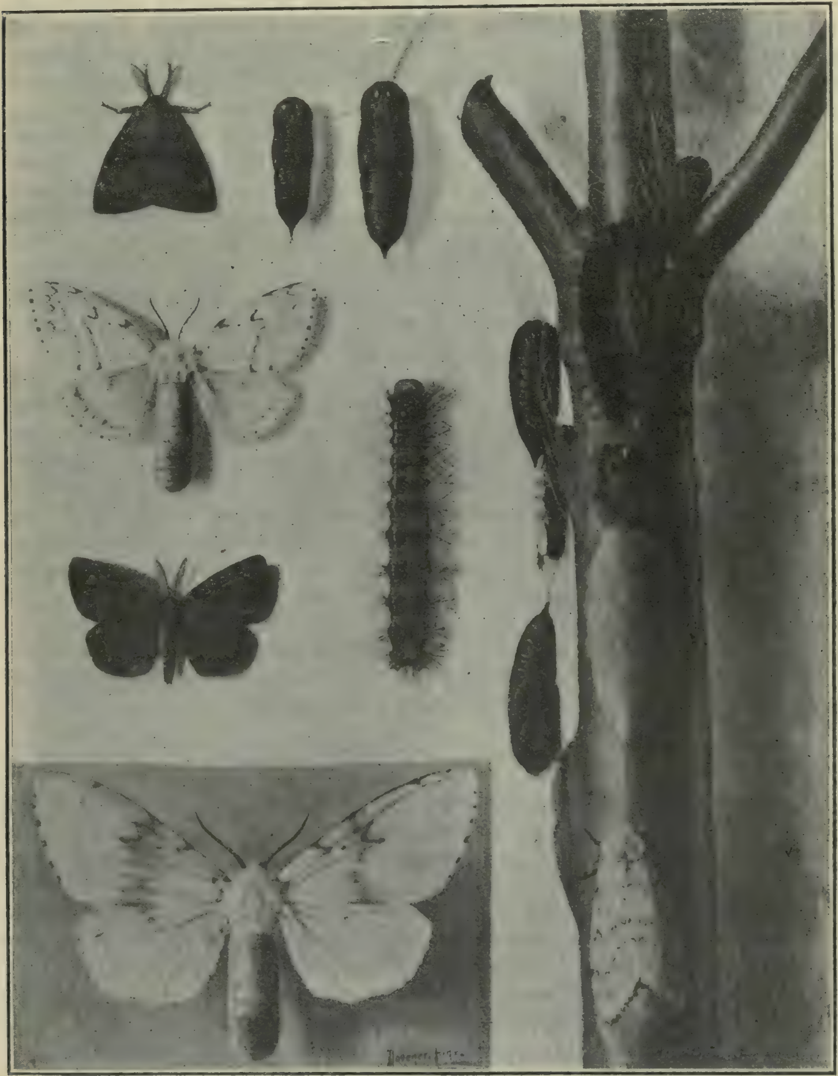


FIG. 3.—Different stages of the gipsy moth: Egg mass on center of twig; female moth ovipositing just below; female moth below, at left, enlarged; male moth, somewhat reduced, immediately above; female moth immediately above, somewhat reduced; male moth with wings folded in upper left; male chrysalis at right of this; female chrysalis again at right; larva at center.

MEANS BY WHICH THE GIPSY MOTH IS SPREAD.

Egg clusters of the gipsy moth, deposited on trees, lumber, stone, or other products that are likely to be shipped, may be carried long distances and cause the establishment of new colonies of the insect.

Spread in this way is prevented by inspection of such products before they are shipped. Caterpillars of this insect may be spread for limited distances by carriage on moving objects, such as trains, horse-drawn vehicles, or automobiles. The danger of such spread is very limited if the roadways are kept free from severe infestation, and under present conditions in the infested territory danger of spread in this way is not great. New colonies are started principally by the spread of newly hatched caterpillars. Experiments have shown that under favorable conditions these caterpillars may be blown by the wind. The temperature must be high enough for the caterpillars to be active and the stronger the wind the greater the probability of their being carried long distances. It has been demonstrated that caterpillars have been carried more than 20 miles in this way, and specimens have been caught in the air 50 feet above the ground, although probably they are carried much higher than this. It is necessary for the temperature to range above 65° F. and for the wind velocity to be 8 miles or more per hour, in order that wind spread of small caterpillars may result.

In the last few years a new avenue for spread of the gipsy moth has developed from the extensive use of the motor truck for long-distance hauling. Fortunately the material hauled is only occasionally of a dangerous nature, but chance of spread in this way is more or less constant.

The recent popularity of automobile camping parties presents another source of danger, particularly during the vacation season. There is a growing tendency, however, to restrict such camps to municipal or semipublic grounds. Under these conditions the danger can be minimized by proper inspection. Warning posters (Fig. 4) are being used in sections where parties are likely to camp, instructing them to examine their effects carefully so that no caterpillars or egg clusters of the insect will be carried away.

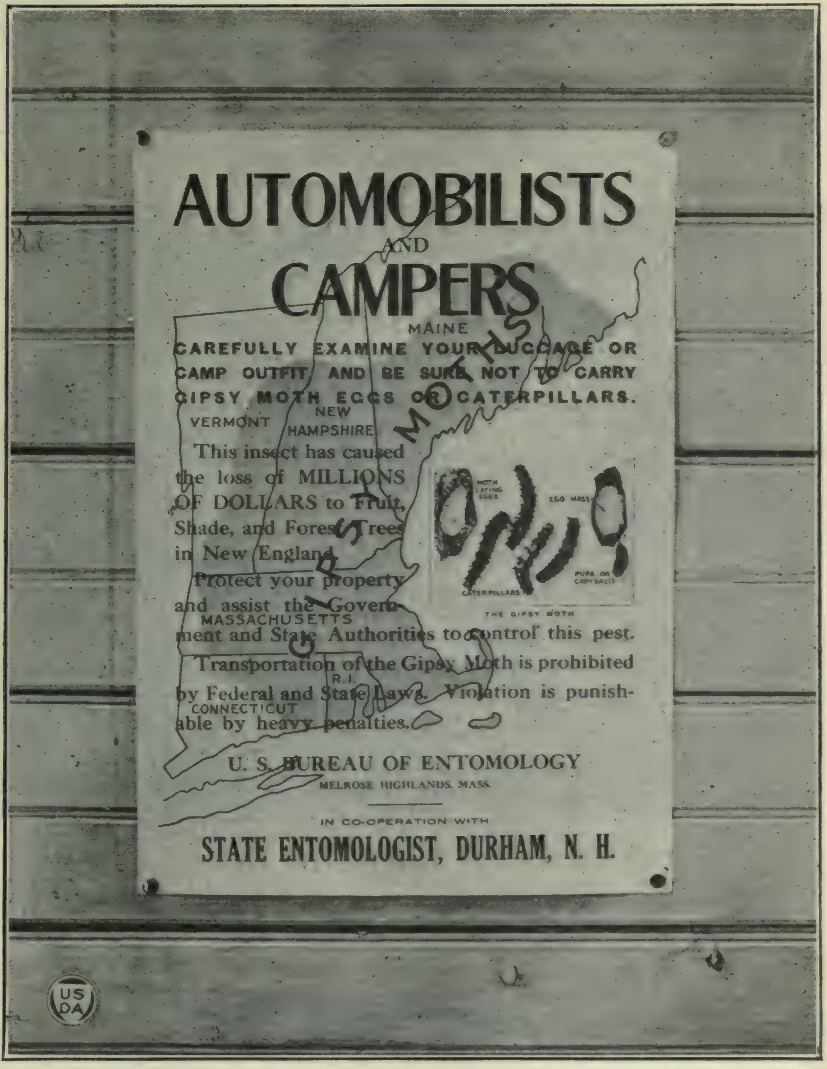
FOOD PLANTS.

The food plants most favored by the gipsy moth are the apple, the different species of oak, gray birch, alder, and willow. In cases of bad infestation nearly all deciduous trees are injured to a greater or less extent, with the exception of ash. Hickory is not a favored food plant, although the foliage occasionally shows severe feeding. Chestnut will not support the gipsy moth when the caterpillars are in the first stage, and pine will not support the first two stages; but if other food plants are present severe injury may result from feeding by the larger caterpillars. Beech is sometimes fed upon freely, and occasionally the trees are defoliated. This is true also of poplar.

INJURY CAUSED BY THE GIPSY MOTH.

Unless reduced in numbers by natural enemies, or by the application of control measures, the gipsy moth is capable of causing enormous injury to tree growth. In the area in New England which has suffered most from this insect thousands of trees are dead as a result of defoliation. (See Fig. 5.) Many areas were cut before the trees were mature and the wood sold at a loss on account of damage caused by this insect. Apple and oak have been injured most, but pine and other coniferous trees mixed with deciduous growth have suffered severely.

It is undoubtedly true that many oak trees which have been weakened severely as a result of defoliation by the gipsy moth and the brown-tail moth have failed to recover because of the attacks of certain wood-boring insects. The species which has caused most damage in this way is a beetle[5] known as the two-lined chestnut borer, the larva of which feeds beneath the bark of injured trees.



AUTOMOBILISTS
AND
CAMPERS

CAREFULLY EXAMINE YOUR LUGGAGE OR CAMP OUTFIT AND BE SURE NOT TO CARRY GIPSY MOTH EGGS OR CATERPILLARS.

This insect has caused the loss of MILLIONS OF DOLLARS to Fruit, Shade, and Forest Trees in New England.

Protect your property and assist the Government and State Authorities to control this pest.

Transportation of the Gipsy Moth is prohibited by Federal and State Laws. Violation is punishable by heavy penalties.

U. S. BUREAU OF ENTOMOLOGY
MELROSE HIGHLANDS, MASS.
IN CO-OPERATION WITH
STATE ENTOMOLOGIST, DURHAM, N. H.

FIG. 4.—Warning poster.

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[5] *Agrilus bilineatus* Weber.

EFFECT OF CLIMATIC CONDITIONS ON THE GIPSY MOTH.

Recent investigations have shown that extremely low temperature during the winter is fatal to the eggs of this insect that have been deposited in exposed situations. From —20° F. to —25° F. is usually required to injure them sufficiently to prevent hatching, and if the clusters are protected by snow, ice, or other material, no injury to them results, even at this temperature. After extremely cold winters many eggs fail to hatch from this cause.

During May when the caterpillars are hatching there are sometimes long periods of cold weather accompanied by heavy rains. This condition, or the occurrence of severe frosts in June, occasionally causes the death of the least hardy caterpillars.

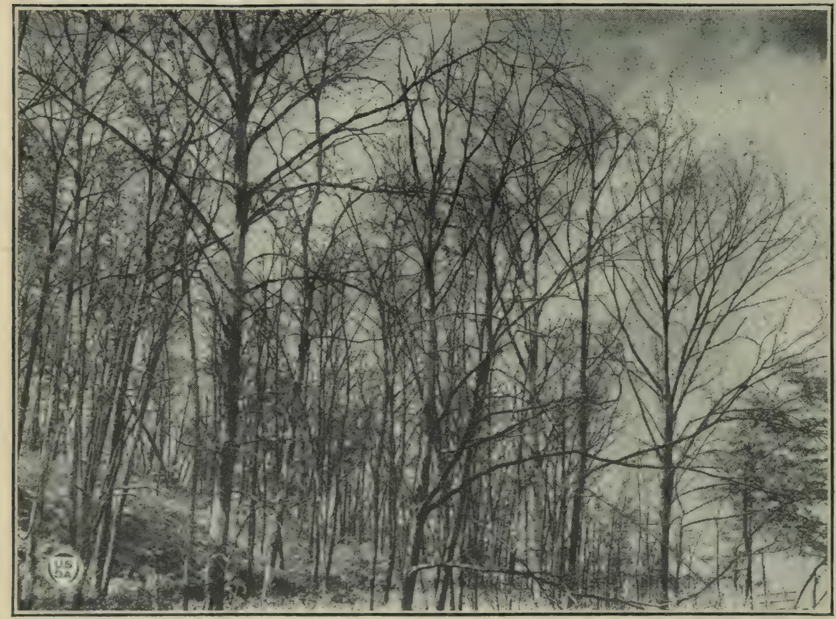

FIG. 5.—Woodland showing dead and defoliated trees due to gipsy-moth attack.

NATIVE ENEMIES.

Few insect enemies of the gipsy moth native to New England cause any noticeable reduction in its numbers. This is shown by the fact that between 1900 and 1905, when no systematic effort was made to suppress the insect, alarming injury resulted, and native insect enemies did not increase to any marked degree. The same is true of the work of native insectivorous birds. While they undoubtedly feed to some extent on gipsy-moth caterpillars, there is no case on record where they have been able to control the species. The "wilt," a disease that attacks and kills the caterpillars and pupæ, has probably occurred in this country for many years. During some seasons, particularly in badly infested areas, it causes the death of an enormous number of the caterpillars and is often an important factor in reducing the infestation locally.

INTRODUCED PARASITES AND ENEMIES.

In 1905 an effort was made by the State of Massachusetts, in cooperation with the Bureau of Entomology, United States Department of Agriculture, to introduce the parasites and natural enemies of the gipsy moth from its native home in Europe and Japan. Since that time a large amount of parasitized material has been received nearly every year, and as a result some promising natural enemies have become established in this country and are assisting in bringing about the control of the species. The enemies which have become established and are at present destroying the largest number of gipsy-moth caterpillars and pupæ are the Calosoma beetle,[6] two species of parasitic flies,[7] one of which attacks the brown-tail moth as well as caterpillars of many native insects, and two species of small wasplike flies,[8] one of which attacks the brown-tail moth. Two tiny parasites of the gipsy-moth eggs have also been introduced and colonized, one[9] from Japan and the other[10] from Europe.

Several other parasites have been introduced and are established in this country, but have not increased sufficiently to be considered important factors in gipsy-moth control.

The work of the natural enemies of the gipsy moth, including the imported parasites, the Calosoma beetle, and the wilt disease, has greatly reduced the numbers of the insect in many localities that are badly infested.

It is hoped that when the enemies of the moth are present in larger numbers over the entire infested territory the insect will become much less destructive than at present.

Colonization of some of the species has been carried on throughout the entire area, but much remains to be done with others, particularly the egg parasites. The records at the Gipsy Moth Laboratory at Melrose Highlands, Mass., indicate that all of the species of parasites mentioned have increased gradually in the field during the last few years, and the results of their work are noticeable in certain areas. Until the natural enemies become more abundant than they are at present throughout the entire infested area it will be necessary to employ the most effective mechanical methods for restricting the spread and curtailing the increase of this species. In the meantime further work is being done in foreign lands, particularly in Japan and Germany, to determine the principal factors that are responsible for the periodical scarcity of the insect there and to take advantage of this knowledge for the purpose of developing more effective natural control in this country.

THE BROWN-TAIL MOTH.

LIFE HISTORY.

The stages of the brown-tail moth are shown in Figure 6.

The eggs.—The female brown-tail moth deposits a small cluster of eggs on the under side of a leaf. These eggs are usually laid in July and are covered with brown hair taken from the body of the female. Hatching begins about the 15th of August.

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[6] *Calosoma sycophanta* L.

[7] *Blepharipa scutellata* Desv. and *Compsilura concinnata* Meig.

[8] *Apanteles melanoscelus* Ratz. and *A. lacteicolor* Vier.

[9] *Schedius kuvanae* How.

[10] *Anastatus bifasciatus* Fonsc.

The larvæ.—The newly hatched larvæ of this insect feed on the epidermis of the leaf and after molting once or twice begin to construct a winter web. This is made by drawing together several terminal leaves and securely fastening them by silk which is secreted by the caterpillars. The larvæ from one or more egg clusters live and feed in common, and as cold weather approaches they retire to the

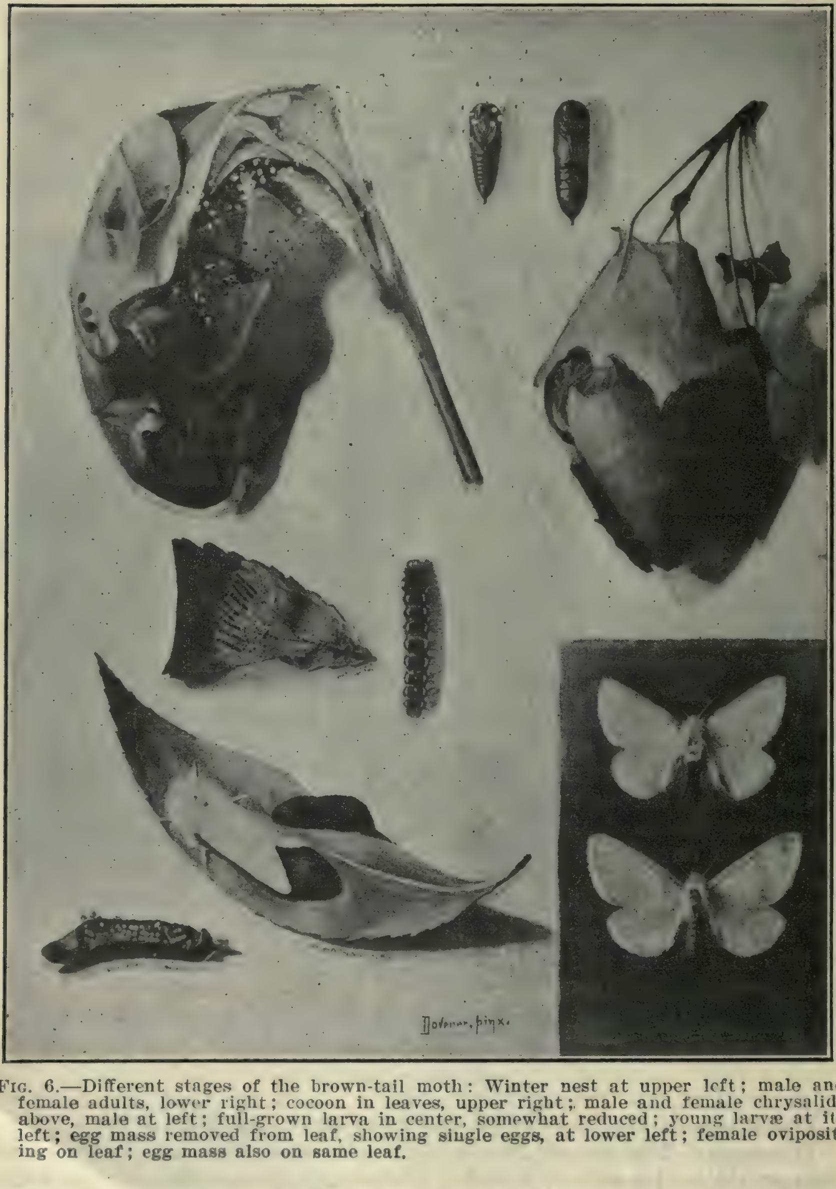
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FIG. 6.—Different stages of the brown-tail moth: Winter nest at upper left; male and female adults, lower right; cocoon in leaves, upper right; male and female chrysalids above, male at left; full-grown larva in center, somewhat reduced; young larvæ at its left; egg mass removed from leaf, showing single eggs, at lower left; female ovipositing on leaf; egg mass also on same leaf.

web, in which they remain during the winter. In the spring these larvæ leave the web as soon as the buds begin to develop and feed upon the bud scales and small leaflets. They become full grown about the middle of June.

The pupæ.—After the caterpillars finish feeding they spin loose silken cocoons and pupate within them. These cocoons are sometimes constructed separately, but in many cases large numbers of them are spun in a single mass. About two weeks are spent as pupæ.

The adults.—Emergence of the moth usually begins the first week in July. The adult brown-tail moth is pure white. The abdomen of the female is much larger than that of the male, but in both sexes the tip of the abdomen is covered with dark-brown hairs. These moths are attracted to strong light, such as electric arc lights; and as they fly at night, it is often possible to secure many specimens around the arc lights in cities and towns during the first half of July.

FOOD PLANTS.

The caterpillars of the brown-tail moth commonly feed on the leaves of apple, pear, plum, oak, and willow, and they are sometimes found in considerable numbers on elm, maple, and rose and in smaller numbers on other common deciduous trees and shrubs. They never attack conifers and are seldom found on hickory, ash, chestnut, or birch.

INJURY CAUSED BY THE BROWN-TAIL MOTH.

The principal injury caused by the brown-tail moth is due to the feeding of the larvæ in the spring. If the infestation is bad the caterpillars are often numerous enough to devour the leaves as fast as the trees are able to develop them. As the webs are made on the terminals, the growth of the trees is often severely checked. In severe infestations trees may be completely stripped (Fig. 7), but as the larvæ become full grown during the first part of June, there is usually an opportunity for the trees to refoliate before midsummer. The young larvæ that hatch in August frequently skeletonize the leaves to a considerable extent. This does not damage the trees seriously, as the growing period for the season is nearly completed.

The bodies of the caterpillars of the brown-tail moth are provided with poisonous hairs. A microscopic examination of these hairs shows that the edges are barbed in such a way that when they come in contact with the human skin and are pressed into the flesh, intense irritation is caused. These hairs are also hollow and contain a poisonous substance which acts on the blood corpuscles. This causes serious poisoning and severe irritation, accompanied with external swelling, which is known as the brown-tail rash. Persons differ considerably in their susceptibility to this poison, but many cases are reported each year in the infested region, most of which are more serious than those of ivy poisoning. Many camps and summer cottages, particularly in wooded areas, can not be occupied with any comfort during the early summer if the caterpillars are abundant, on account of the poisoning due to these caterpillars. If clothing is hung on the line near badly infested trees the hairs frequently find lodgment and are brought into the houses, and severe poisoning may result later.

The brown-tail moth has been less abundant during the last three years than heretofore. There have been local infestations, however, where serious injury resulted.

NATIVE ENEMIES.

One of the important native enemies of the brown-tail moth is a fungus disease[11] which attacks the caterpillars, particularly in the spring. It was first reported in this country by Dr. Roland Thaxter in 1888. Like all diseases of this nature, the benefit derived from it is regulated largely by favorable or unfavorable weather conditions. This fungus sometimes works to a slight degree on the small caterpillars in the fall, and in some instances it is found in the winter webs. As a rule, however, the greatest mortality of caterpillars takes place in the spring, when they are nearly full grown, and the pupæ may, under the most favorable conditions, be almost completely exterminated.

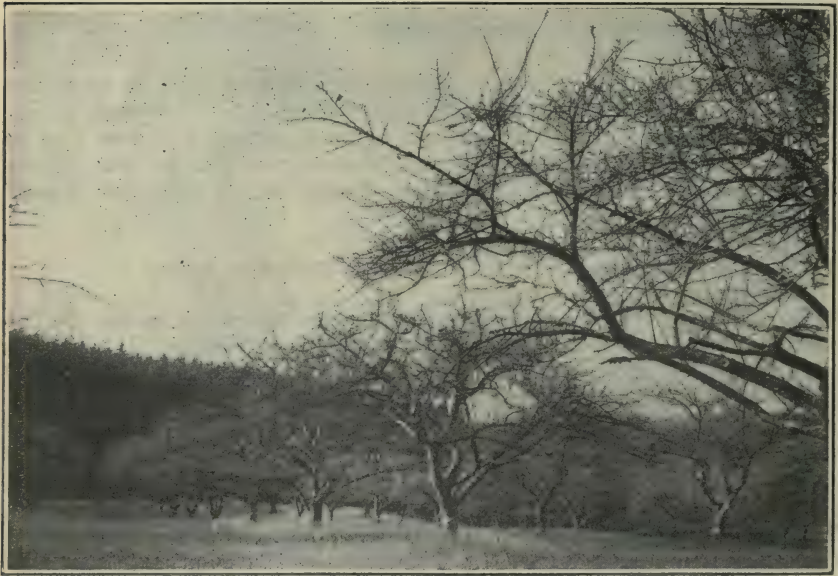

FIG. 7.—Apple trees stripped by brown-tail moth caterpillars. Note old winter webs at tops of trees.

Native parasites and predacious insects have done very little to check the increase of the brown-tail moth.

INTRODUCED PARASITES AND ENEMIES.

Some of the parasites[12] that were introduced as enemies of the gipsy moth caterpillars attack the brown-tail moth freely, and one additional introduced species[13] is an important enemy of the latter insect. The Calosoma beetle,[14] both in the adult and in the larva stage, destroys many brown-tail moth larvæ and pupæ.

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[11] *Entomophthora aulicae.*
[12] *Apanteles lacteicolor* Vier. and *Compsilura concinnata* Meig.
[13] *Meteorus versicolor* Wesm.

The parasites and natural enemies of this insect are more effective than is the case with the gipsy moth, and extremely low temperature in the winter often proves fatal to a large proportion of the small caterpillars in the webs.

These factors, together with an enormous amount of hand suppression that has been employed in many parts of the infested area, have resulted in a pronounced decrease in the abundance of the insect during the last few years.

METHODS OF CONTROLLING THE GIPSY MOTH.

GENERAL METHODS.

Creosote.—One of the best methods of controlling the gipsy moth is to treat the egg clusters of the insect between August 1 and April 1 with creosote, to which a small amount of lampblack has been added. The material is sold by dealers in the infested region under the name of gipsy-moth creosote. It is applied with a brush and leaves a black residue on the clusters treated. Creosote may be obtained from nearly all the large hardware or seed stores in the infested district.

Burlap bands.—Gipsy-moth caterpillars usually seek shelter during hot, sunny days, and if a band of burlap is attached to a tree (Fig. 8), large numbers of them will crawl beneath it, where they may be crushed each day. Ordinarily a strip of burlap about 8 inches wide is placed loosely around a tree trunk and a piece of twine passed around the center and tied to hold it in place. After this is done the top part of the burlap is folded down so that a double shelter is made beneath it. The use of burlap bands has been discontinued during the last few years, owing to the expense involved and because of the fact that if the burlaps are applied early in the season, before the brown-tail moth caterpillars have pupated, an excellent place is furnished for these poisonous caterpillars to make their cocoons, and severe poisoning results to the workmen. If this method is to be used at all, the burlap should not be attached to the trees until after June 15, when most of the brown-tail moth caterpillars will have pupated.

Sticky bands.—Bands of a widely known sticky substance for use in banding trees, which may be obtained on the market, may be used on tree trunks after the bark has been scraped so that the material can be applied evenly in a thin layer with a paddle. The purpose of this band is to prevent caterpillars from ascending the trees, and if previously the egg clusters have been treated, this is a very effective measure. It is necessary every week or 10 days during the caterpillar season to run a comb or other similar implement over the band in order to prevent hardening of the surface and to bring up fresh, sticky material from the part of the band near the bark. (See Fig. 9.) Placing these bands on the trees prevents the caterpillars from reaching the foliage; and as they usually mass in large numbers beneath the bands, conditions are favorable for wilt disease to develop, and the caterpillars often die in large numbers from this cause and from starvation.

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[14] *Calosoma sycophanta* L.

Gipsy moth tree-banding material.[15]—This is a black greasy substance which was prepared and tested by the Bureau of Entomology in cooperation with the Bureau of Chemistry. It is similar to the product known as "raupenleim" that has been used in the German forests for many years to prevent injury to the trees by caterpillars. It is applied with a special "gun" designed for the purpose. (Fig. 10.) A thick, narrow, band is left on the tree trunk, preventing the caterpillars from reaching the foliage. This material is cheap and effective and is easily applied because it is not necessary to scrape the trees before it is put on.

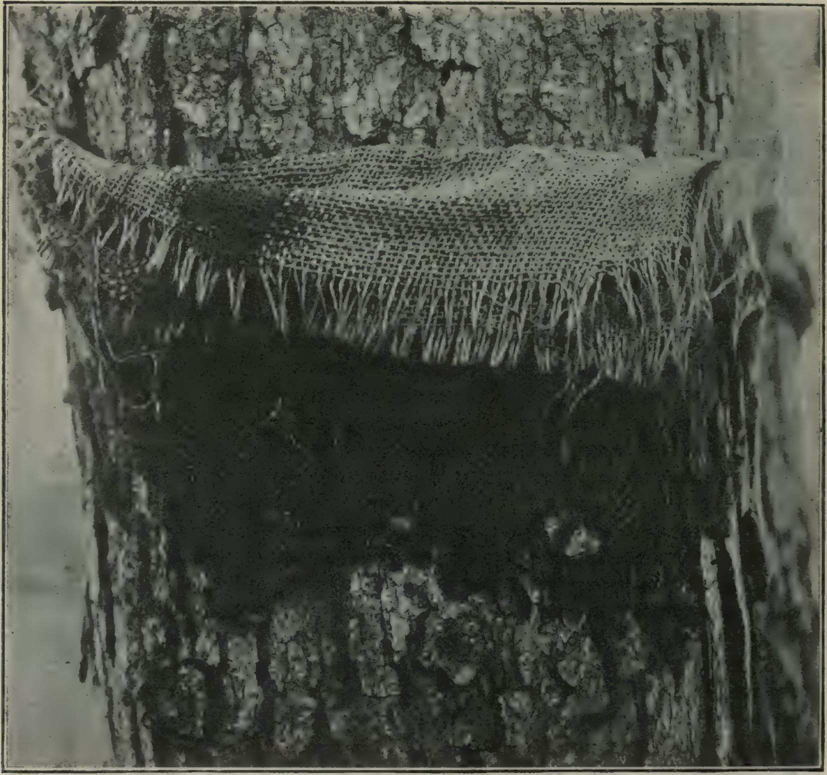

FIG. 8.—Burlap band on tree. The caterpillars beneath it are nearly all those of the brown-tail moth.

Spraying.—The most effective spray material for the gipsy moth is arsenate of lead. It can be used either in the paste or in the powder form. If paste is used, from 10 to 12 pounds is required for each 100 gallons of water. If powder is used, one-half the amount is sufficient for the same quantity of water.

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[15] For full information concerning its preparation and use consult Department Bulletin 899, U. S. Department of Agriculture.

For small operations the ordinary orchard sprayer may be used with one or more lines of hose, depending on the pressure that is available. Nozzles of the Vermorel or Bordeaux type are satisfactory.

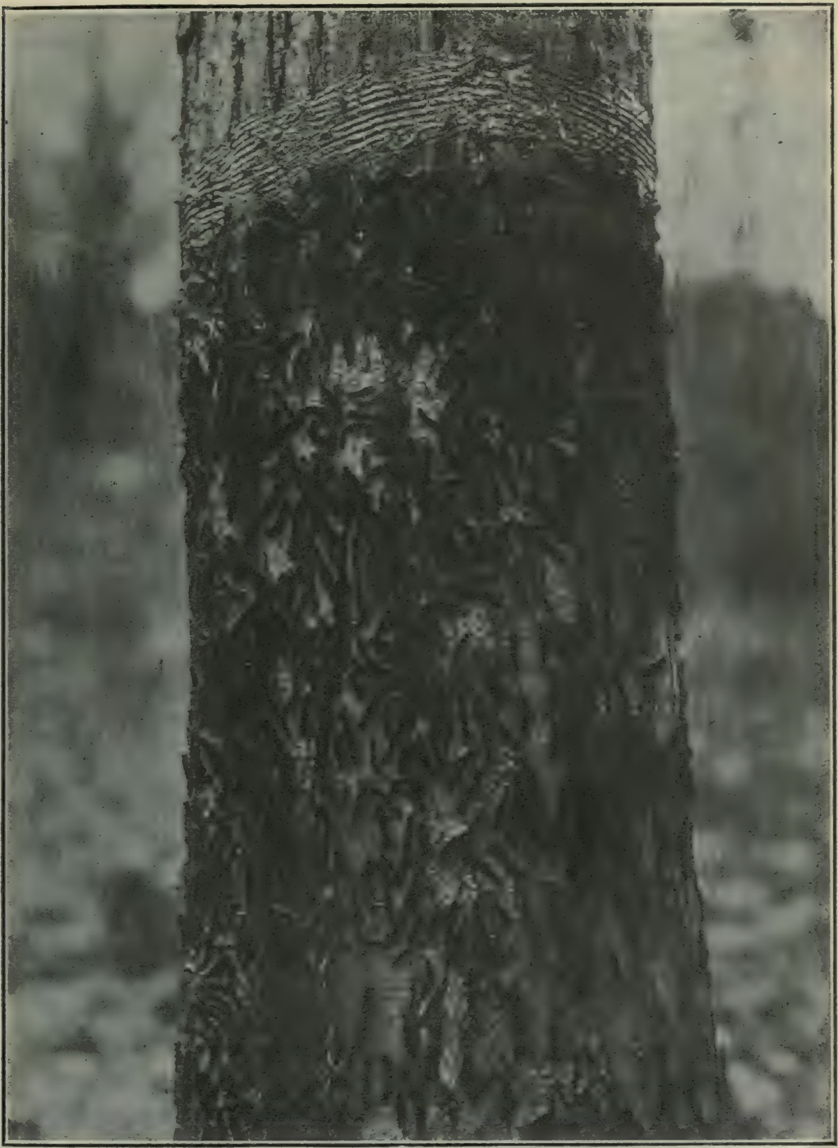

FIG. 9.—Sticky band. Note that there are enormous numbers of gipsy-moth caterpillars below the band, but none above it.

In case large shade trees or valuable park or woodland trees are to be treated, the use of a high-power sprayer is more economical. The type that has given the most satisfactory results in the gipsy-moth work develops sufficient power to throw a solid stream of spray so that it will drift through the trees. (Fig. 11.) The nozzle is constructed so that the stream will break into a fine mist high in the air, and this results in very satisfactory and rapid work. With such a sprayer it is unnecessary to use small hose and climb trees, which is a slow and expensive operation.

A satisfactory high-power sprayer for this work is equipped with not less than a 10-horsepower gasoline engine and a triplex pump capable of delivering at least 35 gallons of liquid per minute at a pressure of from 225 to 350 pounds. This machinery, together with a 400-gallon tank, should be mounted on a well-built truck. One-inch hose is used, and by slightly increasing the pressure at the machine the spray material can be conducted through several hundred feet of this hose with the outfit mentioned without seriously reducing the nozzle pressure, which should be maintained at about 225 pounds.

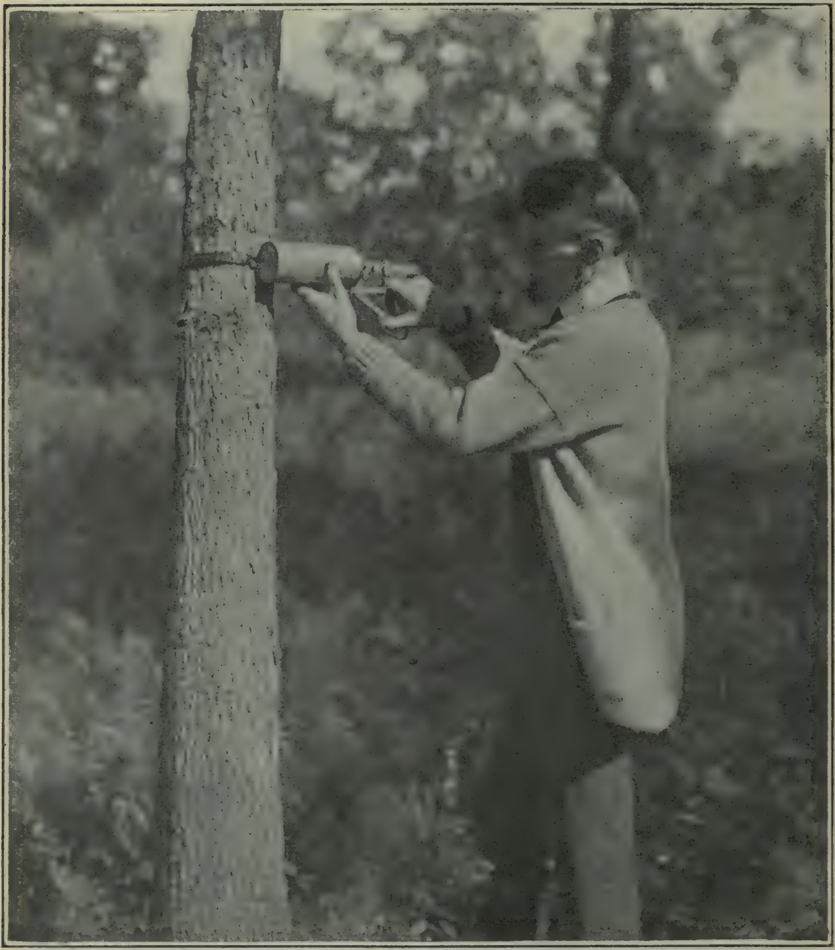

FIG. 10.—Applying tree-banding material to protect the foliage from gipsy-moth caterpillars.

In cases where 1,000 feet or more of hose is to be used the pressure must be increased, and when approximately a mile of hose is required in rough country it is frequently necessary to maintain a working pressure of 1,000 pounds. For such heavy work 1⅛-inch hose gives more satisfactory results than smaller hose, as the friction is considerably less. Pumps of heavier design are necessary, and it is advisable to mount them on motor trucks to make the outfit more mobile. (Fig. 12.)

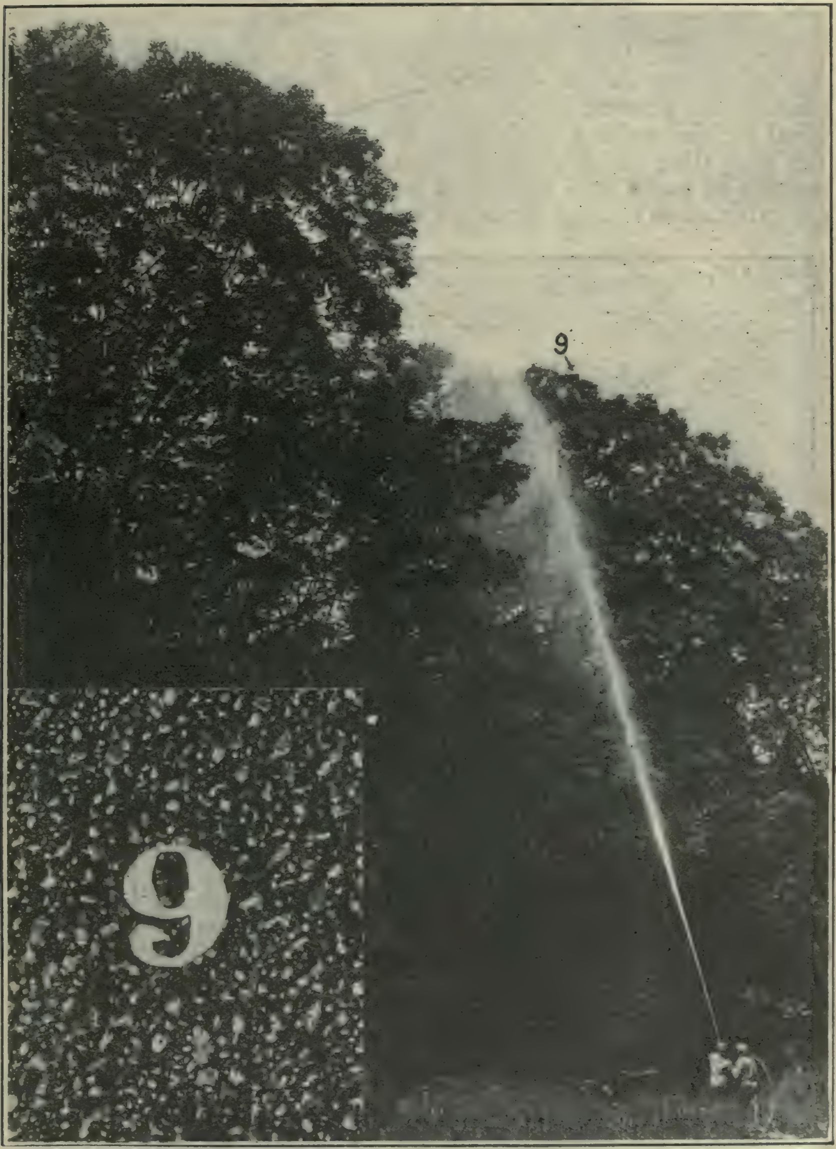

FIG. 11.—Spraying trees 85 feet high with high-power sprayer. Note thorough distribution of poison on plate (9) located at top of tree. (Worthley.)

By using a small device, which is attached to the nozzle and is known as a spreader, it is possible to spray low growth very satisfactorily. Fruit trees can be treated very rapidly in this way. (Fig. 13.)

METHODS TO BE USED IN ORCHARDS.

The methods to be used for controlling the gipsy moth in orchards depend largely on the severity of the infestation. If only a few egg clusters are present in the orchard, the early spraying which is applied for the codling moth after the blossoms fall will be found useful, providing the amount of arsenate of lead used is increased to 10 pounds of paste, or 5 pounds of powder, to 100 gallons of water. If the infestation is more serious, a second spraying early in June, using a similar amount of poison, will be found very satisfactory. Where the infestation is severe, it will probably be necessary to creosote egg clusters in the winter and spray in the spring. Thoroughness is a prime essential if good results are to be obtained.

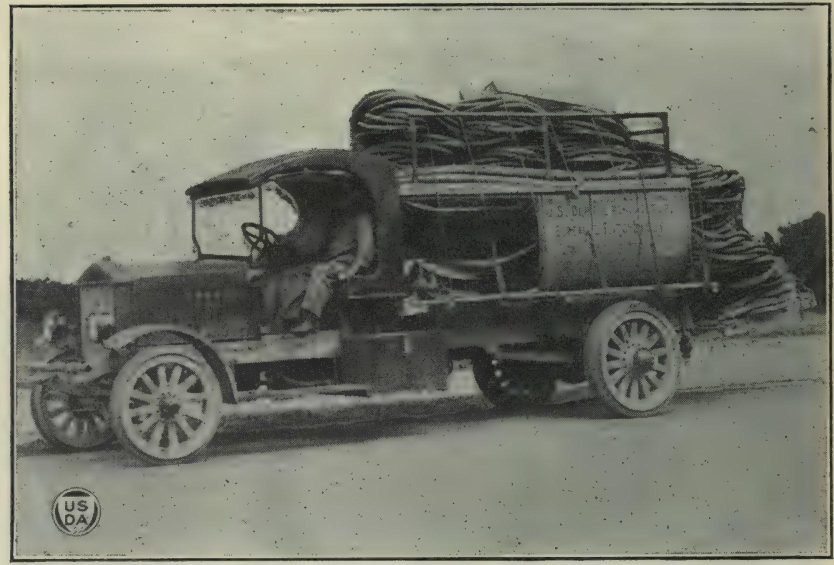

FIG. 12.—Heavy motor-truck sprayer fully equipped.

All poor or hollow trees should be removed; and if badly infested woodland is near by, the orchard trees should be banded. Orchard infestations can be managed by following these methods, and it will not require much additional expense or a great deal of extra work to protect the trees. In making this statement it is assumed that the orchard is being cared for by up-to-date methods to protect it from the codling moth and other injurious insects and diseases, and it is improbable that these results can be brought about in neglected orchards or where the owners do not practice the best horticultural methods in handling their growing trees.

METHODS ADVISABLE IN CITIES AND TOWNS.

The same methods that are used in orchards are applicable in cities and towns and for the treatment of park and shade trees. In certain instances it would probably be advisable to use tree-banding material or burlap, preferably the former, and to discontinue spraying in cases where the infestation is light or moderate. If the infestation is bad, creosoting, banding, and spraying should all be used in their season, in order to bring the insect under control and reduce the numbers present to a minimum.

The method of handling the gipsy moth in any town, city, or park, or on private estates, should be based on the infestation as determined by some one who is familiar with gipsy-moth work, if the best results are to be secured at a minimum expense. Much energy and money may be wasted in applying remedies unless their application is based on a thorough knowledge of existing conditions. An owner of an infested estate should have an examination made by some qualified person who can give reliable recommendations as to treatment. It should be borne in mind that conditions as to infestation vary from year to year, and this should be considered when plans for treatment are being made.

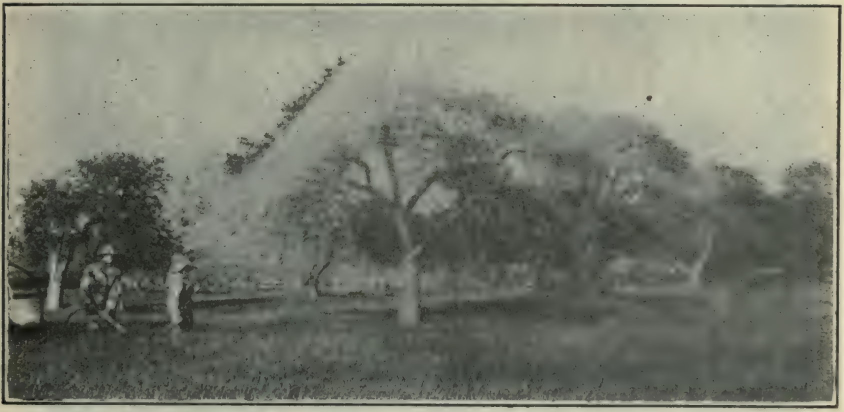

FIG. 13.—Spraying orchard with solid stream, using spreader. (Worthley.)

CONTROLLING THE GIPSY MOTH IN WOODLAND.

Satisfactory control of the gipsy moth in woodland by the employment of hand methods such as have already been mentioned is impracticable under present conditions, unless the tree growth is particularly valued for purposes other than lumber. If the woodland is situated near a large city and occupies space that is likely to be utilized in a few years for building lots, considerable money may be expended to advantage in protecting the trees, as these will make the property much more valuable when the land is subdivided. Limited areas of woodland on private estates may be of sufficient value to the owners to justify a considerable expenditure for moth destruction. In all cases, however, the species of trees involved should be carefully studied before a plan of work is adopted, in order that the expense may be reduced as much as possible. Unfortunately the difficulty of treating the woodlands in the infested area of New England is considerably increased by the fact that they are for the most part composed of a variety of species in mixture.

Experiments have shown that most coniferous trees are not injured by the gipsy moth if grown in isolated pure stands; and if the growth is such that the trees can be thinned to a stand of immune species, no hand suppressive measures are necessary in order to prevent injury by this insect. Such lots will not be attacked by the brown-tail moth, as the larvæ of this insect do not feed on conifers.

If mixtures containing a large percentage of deciduous trees are to be protected from moth injury, it is very necessary that the species involved should be carefully considered before a decision is reached as to the best methods of treatment. Sometimes practical methods of thinning (Figs. 14, 15) can be adopted so that species will be left that are only slightly subject to injury by these insects. A limited number of experiments have shown that mixtures of chestnut, pine, red maple, ash, and hickory, regardless of the proportion of each species, are seldom injured by the gipsy moth.

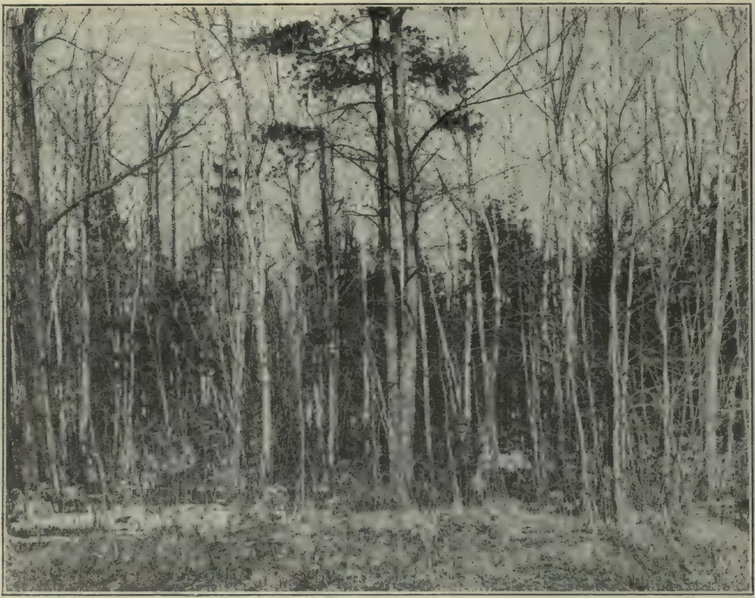

FIG. 14.—Mixed deciduous and coniferous woodland before thinning.

In woodlands the oaks are the most favored food plant of this insect, and, unfortunately, the infested region abounds in large areas where these species predominate. At present there seems to be no means aside from hand treatment which will prevent serious injury to oak woodland, but, as a large part of such land consists of poor sprout growth, the amount of damage sustained is not always so great as it might at first appear. The greatest injury likely to be caused in such areas where oaks and gray birch abound is the dying of small seedlings of pine or other valuable species which have been denuded by the caterpillars after the oaks and birches have been defoliated. This leaves the prospective woodland in a much worse condition than it was before the defoliation took place and reduces greatly the chance that the sprout growth will be replaced by any species of value that can withstand gipsy-moth attack. Special study and consideration is being given to devising some economical method for protecting and improving wood lots of this character at moderate expense. It is true that in considerable areas of oak woodland the trees, although not mature, could be utilized for small timber, railroad ties, or cordwood, and in cases of bad infestation such woodland should be promptly cut if the wood can be sold to advantage. On cheap cut-over or infested lands in many sections of the territory white pine might be planted to advantage, but as this involves considerable expense and as the future crop can not be harvested for a period of years, the question as to the desirability of managing any wood lot in this way must in the end be decided by the owner of the property.

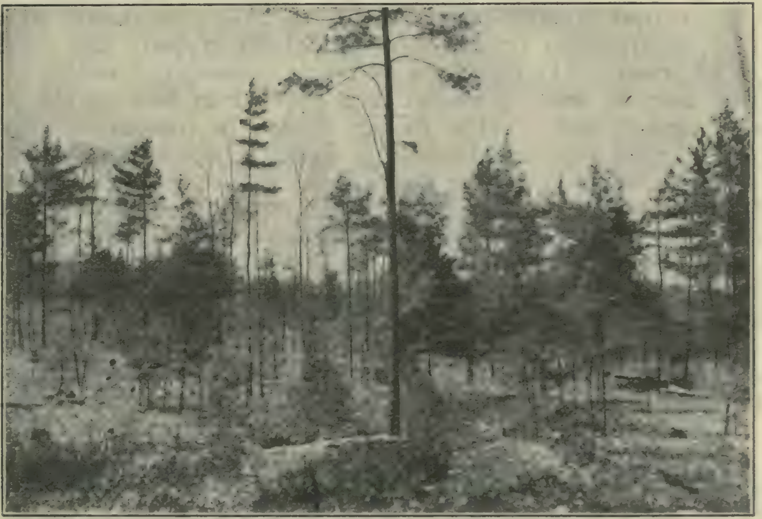

FIG. 15.—Same woodland after growth favored by the gipsy moth has been removed by thinning.

If the practice common in some European countries of maintaining municipal or State forests were well developed in the New England States, it would be possible in a period of years to transform considerable areas of land which are now destined to be worthless, and which form a favorable feeding ground for the gipsy moth, into well-managed forests of valuable growth.

METHODS OF CONTROLLING THE BROWN-TAIL MOTH.

The brown-tail moth can be controlled by cutting off the winter webs and burning them before the caterpillars begin to emerge in April. *These webs should be destroyed by fire*, for if they are simply cut from the tree and left on the ground the caterpillars will emerge and no benefit will result from the work which has been done.

In orchard practice it is sometimes inadvisable to cut the winter webs, for where an infestation is bad it is likely to leave a poorly shaped tree. Spraying in the spring is not a satisfactory remedy unless the infestation is very light, because the caterpillars, when they occur in large numbers, do not allow the tree to put out sufficient foliage to hold the spray material.

The most effective method in orchards is to spray the trees before the middle of August, using from 3 to 5 pounds of arsenate of lead powder to 100 gallons of water. Before spraying operations of this sort are attempted determine to what extent the trees are infested with egg masses of the brown-tail moth. If the infestation is very slight, it will be more satisfactory to cut and destroy the webs. If the infestation warrants, both shade, ornamental, and fruit trees may be sprayed to advantage at this time. Caution should be used, however, in spraying fruit trees, particularly if early fall varieties are to be treated. If this is to be done, a somewhat weaker spray solution may be used, provided it is applied as soon as the caterpillars begin to hatch. The foliage should be treated thoroughly, particularly the terminal shoots, and as much care as possible should be exercised not to cover the fruit. Late fall or winter varieties of fruit may be sprayed in August with arsenate of lead, using 3 pounds powder to 100 gallons of water, and although an occasional spot may be found on the fruit at the time of picking no injury will result from it. In cases where only a few choice fruit trees are sprayed it is practicable to wipe the fruit before packing for sale; but this will not be necessary if care is taken to spray only the terminal growth of the trees, as this is where the bulk of the egg clusters are deposited.

CONTROLLING THE BROWN-TAIL MOTH IN WOODLAND.

The damage caused by the brown-tail moth is ordinarily not so severe as that resulting from gipsy-moth infestation, because the former species does not have so wide a range of food plants and, further, because the bulk of the feeding by the larvæ of the brown-tail moth is done early in the season, so that the trees have an opportunity to recover before midsummer. In the territory where both insects exist the caterpillars of the gipsy moth supplement the work which is done by those of the brown-tail moth, and the injury is, therefore, greatly increased.

During the last few years this insect has seldom been found feeding on oak foliage, except in the worst-infested localities, and elm trees are not as badly infested as was the case about 10 years ago.

Thorough destruction of brown-tail moth webs in residential sections and in orchards has resulted in materially decreasing the insect in thickly settled sections. Elimination of worthless apple and wild cherry trees would help greatly in reducing the pest.

ORGANIZATION AND STATUS OF WORK AGAINST THE GIPSY MOTH AND THE BROWN-TAIL MOTH.

STATE WORK.

Each of the New England States is carrying on work for the control of the gipsy moth and the brown-tail moth. The organization varies because of local conditions, but the same general methods of field work are employed.

In Maine the work is in charge of the commissioner of agriculture, who has authority to appoint a superintendent of moth work. The southwestern portion of the State is from generally to badly infested with the gipsy moth, while in the outlying area only scattering infestations have been found. The brown-tail moth is not now seriously abundant, but is found most commonly along the coast and near the main watercourses. Ten thousand square miles of territory in Maine are infested with the gipsy moth and about 7,000 with the brown-tail moth. The former has gradually spread to new territory, but the area infested by the latter has decreased sharply during the last five years.

In New Hampshire the moth work is in charge of the State entomologist. Over 7,000 square miles of territory are infested with the gipsy moth and about 3,600 with the brown-tail moth. The heaviest gipsy-moth infestations in the State are south of the latitude of Lake Winnepesaukee.

In Vermont the moth work is in charge of the commissioner of agriculture, who appoints a deputy to carry on the field work. During the last three years the territory infested with the gipsy moth has increased rapidly and over 2,000 square miles are now known to be infested. The brown-tail moth has not been found in the State during the last two years except a few webs discovered during the winter of 1922–23 in two towns bordering the Connecticut River.

The commissioner of conservation has charge of the moth work in Massachusetts. Each infested town is required by law to select a local superintendent, whose appointment must be approved by the commissioner. Owners are required by law to keep their property free from these pests, but can not be compelled to expend for this purpose more than $5 on each $1,000 assessed valuation. Towns and cities must expend funds for proper treatment of the street trees and those in parks and on public grounds. After the amounts fixed by law are expended, financial aid is supplied by the State. The gipsy moth at present occurs to a greater or less extent in nearly every town in the State, but most of the territory west of the Connecticut River is lightly infested. The area infested by the brown-tail moth has been reduced so that at present it amounts to only a little over 4,000 square miles.

In Rhode Island the State board of agriculture has charge of the moth work, which is done under the supervision of the State entomologist. The gipsy moth occurs in all towns in the State, but is most abundant in the northern part. The brown-tail moth infestation has decreased rapidly in the last few years and at present none of the towns are known to be infested.

In Connecticut the work is in charge of the State entomologist. The brown-tail moth has not been found in this State for several years. The gipsy-moth area has increased rapidly during the last three years, and nearly 2,000 square miles are now known to be infested. The food plants in this State are favorable to the rapid increase of the insect, but, although scattering infestations have been found over a much larger area than heretofore, thorough treatment has prevented injury to trees from this insect up to the present time.

In New York State the field work against the small number of scattered infestations that have been found has been supervised by the director of the Bureau of Plant Industry of the Department of Farms and Markets.[16] Close cooperative arrangements have existed between that office and the Bureau of Entomology of the United States Department of Agriculture, and both organizations have expended funds in defraying the expenses of the control work.

In New Jersey the State work is under the control of the department of agriculture. The funds appropriated have been used in conjunction with Federal funds and the direct supervision of the work has been in the hands of the United States Bureau of Entomology. The results up to the present time have been very satisfactory.

Work on one small colony in Pennsylvania and another in Ohio was done by arrangement with the State officials—in Pennsylvania with the bureau of plant industry of the department of agriculture of that State and in Ohio with the State nursery inspector. The results were satisfactory, as both colonies of the insects have been exterminated.

WORK OF THE BUREAU OF ENTOMOLOGY.

The work of the Bureau of Entomology of the United States Department of Agriculture against the gipsy moth and the brown-tail moth is designed to prevent the spread of these insects. For a number of years it was believed to be quite impossible to restrict the spread of the brown-tail moth on account of the heavy migration of the adults of this species. In recent years, owing principally to the effectiveness of parasites introduced by the bureau, winter conditions unfavorable to the insect, and in some sections the effectiveness of a fungous disease which attacks the caterpillars, in addition to a large amount of hand-suppression work, it has been possible not only to prevent spread but to record a marked reduction in the infested area. In certain sections near the seacoast in northern Massachusetts and New Hampshire and near some of the rivers, however, rather heavy infestations exist. One of the dangers in connection with the brown-tail moth at present is that favorable climatic conditions or temporary scarcity of natural enemies may enable it to increase rapidly and spread proportionately.

The gipsy moth was held in check for several years and did not spread beyond the Connecticut River. During the war period, when extreme difficulty was experienced in maintaining a field force on an effective basis, infestations developed rapidly, and as the result of favorable winds immediately following the hatching period, extensive spread of the insect to the west and northwest resulted.

Recent field work indicates that many colonies were established during that period, and scattered infestations have been found in the Berkshire Hills section of Massachusetts and Connecticut and in the Green Mountain Range in Vermont. This territory is extremely rugged and very difficult for field operations.

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[16] In March, 1923, the gipsy-moth work was transferred to the Department of Conservation.

A project is under consideration at present of selecting a zone west of this area but east of the Hudson River, where the territory is more favorable for field operations, with the purpose of operating therein and preventing further westward spread.

In town or city work the Bureau of Entomology advises that careful attention be given to woodland infestation or isolated trees, particularly if they are located on high elevations immediately outside the residential area, as colonies in such locations may furnish a supply of caterpillars which will be distributed throughout the town after it has been cleaned. Under present conditions, owing to the decrease in the severity of gipsy-moth infestation in many sections, spraying becomes an economic means of treatment and in some cases is used exclusively for control.

A large amount of experimental work has been done to devise better methods of controlling these insects. Natural enemies have been introduced from Europe and Japan and colonized throughout most of the infested area. Specialists have spent considerable time studying these insects in their native homes and collecting parasites for shipment to this country. This phase of the work is being pressed as rapidly as possible. Investigations looking toward the planting and growing of forest trees that are not subject to attack by this insect are being continued.

The entire area known to be infested by either of these insects is under quarantine by the Federal Horticultural Board, and shipments of nursery stock, lumber, cordwood, and other forest products, and stone and quarry products, are not permitted to leave the territory unless they are inspected and accompanied by a certificate stating that they are free from infestation.

COOPERATIVE WORK.

Since the gipsy moth and brown-tail moth work was begun by the Bureau of Entomology more or less work has been done in cooperation with the States concerned. The introduction of parasites and natural enemies of the gipsy moth was conducted in cooperation with the State of Massachusetts for several years. After the infestation had covered large areas in other States an arrangement was made for this work to be carried on by the Bureau of Entomology. The general plan of field work in New England is for the bureau to handle the territory embracing several tiers of towns along the outside border of gipsy-moth infestation, while the States manage the work inside this area.

The work in New Jersey is planned with the purpose of exterminating this large infestation, and close cooperation with that State has been maintained.

The New England quarantine covers the entire infested area, while the experimental work, including the introduction and colonization of parasites, is being carried out in a systematic way for the purpose of developing better methods for the use of all concerned to bring about the dispersion of the various parasites over the entire infested area as rapidly as possible.

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Gipsy Moth and Brown-Tail Moth Investigations.	A. F. BURGESS, *Entomologist in Charge.*

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U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1336

FEEDING AND MANAGEMENT OF DAIRY CALVES AND YOUNG DAIRY STOCK

1862 1889

STRONG, healthy calves are more likely to be dropped by well-nourished cows. The best time to wean the calf is after it has taken the first milk. Early weaning makes it easier to teach the calf to drink.

Everything about the calf should be scrupulously clean.

Milk from infected cows or from a creamery should be pasteurized before it is fed.

Calves should be fed sweet milk of a uniform temperature and should always receive a little less than they desire.

All calves should be fed regularly; very young calves should be fed three times a day.

At first the calf is fed whole milk, the quantity being gradually increased. Skim milk is substituted as soon as practicable and if cheap is continued until the calf is 6 months old. Ordinarily the maximum quantity of skim milk that can be fed economically is 20 pounds a day. When the calf is 2 weeks old, grain and bright, clean hay should be offered; the quantity fed should be increased as the calf's appetite demands.

Milk substitutes are not equal to milk, but give fair results when used with care.

Quarters must be clean and dry, with plenty of bedding.

Stanchions save milk and prevent the calves from sucking one another.

Horns are more easily prevented than removed.

Water is necessary for calves.

Marks for identification should be plain without disfiguring the animal.

Calf diseases are largely the result of filth and carelessness. Prevention is cheapest and best.

Young dairy stock should have all the hay they will eat, and grain in proportion to weight.

The heifer should be bred to freshen when about 2 years old. Handling before freshening prevents shyness.

Fall calving usually gives best results.

The young bull should have an abundance of feed, plenty of exercise, and not too heavy service.

The foregoing points on feeding and management of the dairy calf are discussed somewhat fully in this bulletin.

This bulletin is a revision of and supersedes Farmers' Bulletin 777.

Washington, D. C. Issued June, 1923.

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FEEDING AND MANAGEMENT OF DAIRY CALVES AND YOUNG DAIRY STOCK.

By W. K. Brainerd and H. P. Davis,[1] *Dairy Division, Bureau of Animal Industry.*

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FEEDING AND MANAGEMENT OF THE DAIRY CALF.

FEEDING BEFORE BIRTH.

POORLY nourished cows often give birth to weak, puny calves which are hard to raise. The feeding of the calf, therefore, begins before it is born. The food elements necessary for the development of the calf are taken into the stomach of the cow, digested, assimilated, and transmitted to the calf through the umbilical cord, the connection between the mother and the calf. It is evident that if the cow does not receive food enough to keep herself in thrifty condition and at the same time develop her calf, the calf may suffer. In endeavoring to raise good, thrifty calves many dairymen handicap themselves at the start by not properly feeding the pregnant cows. Such cows should have an abundance of palatable feed in order to insure good body flesh and thrifty condition at calving time. The calves will then be well developed, strong, and more likely to respond normally to proper feed and care.

SEPARATION FROM THE COW.

It is assumed that the calf is not to be raised by sucking the cow, but is to be fed by hand. The longer it sucks, therefore, the more difficult it will be to teach it to drink. On the other hand, the first

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[1] Mr. Brainerd died in May, 1915, and Mr. Davis resigned in April, 1919.

(or colostrum) milk of the cow possesses properties which stimulate the calf's stomach and other digestive organs to action. Colostrum is nature's physic, and for this reason the young calf should always receive its mother's milk at first. The calf is sometimes weak at birth, and for this reason should have nourishment as soon as possible. It is usually easier to induce the calf to suck the cow than to try to make it drink from the pail. Because of these facts most dairymen prefer to let the calf remain with its mother for about 48 hours immediately after birth. An additional advantage of this practice is that the dam will carefully dry the calf by licking within the first few hours of its life. In the case of a weak calf or one that does not gain strength readily it may be best to allow it to remain longer than 48 hours, although under such circumstances it is sometimes difficult to teach the calf to drink.

TEACHING THE CALF TO DRINK.

It is desirable that the calf be in thrifty, vigorous condition when it is taught to drink. It should be kept without food for at least 12 hours, at the end of which time it will be hungry and will usually drink milk from the pail much more readily than when not hungry. Warm, fresh milk from the mother should be put into a clean pail and held near the floor, in front of the calf, which will generally begin to "nose" about the pail. Once it gets a taste of milk, it will often drink without further trouble. Usually, however, it is necessary for the attendant to put one or two fingers into the calf's mouth, drawing the hand down into the milk as the calf begins to suck the fingers. The calf in this way gets a taste of the milk and oftens begins to drink without further coaxing. If not, the process must be repeated. Sometimes, however, the calf can not be induced to drink in this way, and force has to be resorted to. In such case the feeder, facing the same direction as the calf, should straddle its back and back the animal into a corner. The pail of milk should be held in one hand and the nose of the calf grasped with the other, two fingers being in its mouth. The nose of the calf is then forced into the milk, when it will usually begin to drink. (See illustration on title-page.)

Sometimes a valuable calf, too weak at birth either to suck the cow or to drink from a pail, can be saved by feeding from a bottle, either with or without a nipple.

CLEANLINESS THE FIRST ESSENTIAL.

Cleanliness is absolutely essential to the successful raising of calves. This is equally necessary in feed, pens, bedding, and pails or utensils. All milk fed should be fresh and clean, and the same is true of other feeds. Calf pens should always be kept clean and filled with plenty of dry bedding. Great care should be taken in washing the milk pails. These should be thoroughly scalded with boiling water, or sterilized with steam if possible. Discarded feed should be removed from the feed boxes, which should be thoroughly brushed and cleaned each day. Attention to these details is the best preventive of disease. Nearly all disorders or diseases of the calf are caused either directly or indirectly by lack of cleanliness.

Certain infections causing chronic diarrhea or scours, either contagious or otherwise, are discussed under the head of "Diseases," but there are many small disturbances of the calf's stomach and digestive system which hinder growth and development that are caused by bacteria. Filth and dirt are the natural breeding places of bacteria. Elimination of filth usually means freedom from disease.

PASTEURIZATION OF MILK.

Milk from cows infected with a communicable disease, such as tuberculosis, should always be pasteurized (heated to 145° F. and held at that temperature for 30 minutes) before it is fed to calves. When separated milk from a creamery is fed it should always be pasteurized, because it is practically impossible to know that such milk is free from infection.

QUANTITY AND QUALITY OF MILK.

The quantity of liquid feed that a calf needs depends upon the size and age of the calf and to some extent upon the kind and condition of the feed. At birth a 50-pound calf should have about 8 pounds a day, while a 100-pound calf should have about 12 pounds. (See Fig. 1.) It is better to underfeed at the start than to overfeed. Many beginners make the mistake of letting the calf have all the milk it wants. This would probably be all right if the calf were fed about every two hours, as is the case when it runs with the cow. When a young calf which has been without feed for 12 hours or more is given all the milk it will take there is danger that it will gorge itself, thus causing digestive troubles. It is much safer to keep the quantity of feed well below the capacity of the calf than to risk overfeeding.

Care should be taken to see that any milk fed the young calves is of uniform temperature, about 90° F. Many feeders attempt to overcome poor quality in the feed by increasing the quantity; that is, they feed more skim milk than they would whole milk, the idea being that the added amount of the former makes up for the butterfat which has been removed from the latter. This is radically wrong. The same rules hold good in overfeeding with skim milk as with whole milk. When, on account of age, souring, dirt, etc., the quality of the milk is poor, the quantity fed should be reduced rather than increased, because the danger from infection by such milk is very much greater than from fresh milk, and the prevention of digestive troubles should always be uppermost in the mind of the feeder. The loss of development in the calf on account of a temporary reduction in the ration when for any reason it is sour or nearly so is much less than when the digestive system becomes disordered. A calf can often take a relatively small quantity of bad milk for long periods and still hold its own or even make small gains, whereas a larger portion would endanger its life or give it digestive troubles of a serious nature.

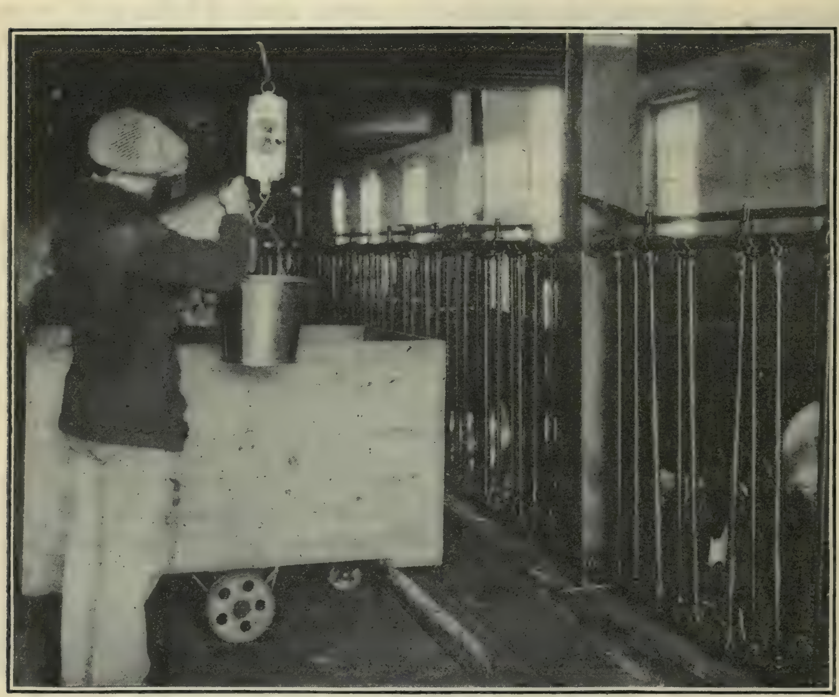

FIG. 1.—Weighing the milk for the calf.

FREQUENCY AND REGULARITY OF FEEDING.

Under natural conditions the young calf receives nourishment every 2 or 3 hours. In hand feeding it is best to follow these conditions as closely as possible, but because of the trouble and expense involved it has been found impracticable to feed calves more frequently than three times a day. They are usually fed only twice a day.

It is the practice of many dairymen to feed young calves three times rather than twice a day, because the better results obtained more than pay for the additional work. When this is done the periods between feeding should be as nearly equal as possible. The chief advantages of feeding in this manner are that the calf can not overload its stomach, and that the digestion of the feed is more evenly distributed throughout the 24 hours. When calves are fed only twice a day the utmost care should be observed to see that the feedings are, as nearly as possible, 12 hours apart.

FEEDING DURING THE FIRST FIVE WEEKS.

At least four-fifths of all dairy calves are raised on separated milk, grain being used to supply the fat removed. Usually it pays well to feed whole milk for about two weeks, at the end of which time separated milk may be used in part. The proportion of the latter may be gradually increased until at the end of the fourth week it is used altogether. No fixed rules of feeding, based upon age, can be given, because the size and vigor of the calf must always be considered. Calves especially strong at birth may be put on separated milk entirely at two weeks of age, but this should not be attempted with weak ones. Until the calf is in vigorous and thrifty condition no attempt should be made to change to separated milk. This change should always be made gradually. The schedule given below for feeding calves is suggested as a guide, but it will often have to be modified to suit conditions. The supplementary feeding of roughage and grain to young calves is mentioned later under the respective headings.

FIRST AND SECOND WEEKS.

For the first four days, from 8 to 12 pounds of milk from the dam should be fed. After this time the milk may be from any cow or cows in the herd, but preferably not from any that are nearly dry. Milk containing not more than 4 per cent of butterfat is considered the best for this purpose.

THIRD WEEK.

At the beginning of the third week the substitution of either skim or separated milk may commence at the rate of 1 pound a day. The quantity of the daily ration may be increased 2 to 4 pounds, depending upon the vigor of the calf. The quantity, however, should be kept well below the capacity of the calf; that is, when it does not drink eagerly what is offered, the quantity should be cut down. In most cases, at the end of the third week the ration should be approximately one-half whole and one-half separated milk. Any increase should be made slowly so as to accustom the calf to the additional amount.

FOURTH WEEK.

At the beginning of the fourth week, from one-half to three-quarters of the milk ration should be separated milk. During the week the change should be continued until by the end of the week only separated milk is fed. With especially vigorous calves the change to separated milk may be made about a week earlier.

FIFTH WEEK AND THEREAFTER.

After this time separated milk may be fed altogether unless the calf is very delicate. The quantity fed can be gradually increased until 18 to 20 pounds a day are given. It is usually not economical to feed more than this unless milk is very plentiful.

The time that milk should be discontinued depends upon its cost in relation to the value of the calf, its breed, size, vigor, etc. The season in which it reaches the age of six months and the other feeds available at that time must also be taken into consideration. Six months is probably a good average age at which to wean calves from milk. When the best of hay, silage, and a good variety of grains are available, the calf may be weaned earlier than when such feeds are lacking. The season of good, succulent pasturage presents the best possible condition for weaning a calf, and when this exists the calf may be weaned earlier than when it is lacking. The stronger and more vigorous the calf the earlier it may be weaned with safety. On the other hand, the more valuable the calf the more expense the owner is warranted in incurring to develop it and the later it will probably be weaned. If skim or separated milk is plentiful. calves may be fed profitably until they are 8 or 10 months old.

When the calf is 2 months old, if it is carefully watched, sour milk, whether whole, skim, or buttermilk, may be fed without harmful results, provided the change from sweet milk is made gradually.

ROUGHAGE FOR CALVES.

Usually a vigorous calf begins during the second week to pick at the bedding or other material within its reach, and at that time both grain and roughage of the best possible quality should be provided. Clover hay, alfalfa hay, or, if these are not available, the most palatable roughage on hand should be given the calf after the second week. If alfalfa is used, care should be taken that it does not cause scours; this feed should be fed sparingly at first and increased only after the calf gets accustomed to it. The essential points are that the roughage be of good quality and kept clean. The usual mistake in providing roughage is that it is not kept clean. It is either placed on the floor, where it soon becomes contaminated with the droppings, or is put into a manger or feed box, so placed that the calf can easily spoil it. Hay should be furnished at first only a handful at a time and placed so that it can not get soiled. A latticework rack, of metal or wood, is useful if it is placed high enough from the floor so that the calf can not soil the hay in any manner, yet can have it within easy reach. This rack may be so constructed that it can be hung on the wall or framework of the stall or pen and removed when not needed. For the first six months, at least, the calf should receive all the roughage of good quality that it will eat up clean. The quantity it will take up to the time it is one month old is very small. The rack should be emptied every day and fresh roughage supplied.

Silage may be given after the calf is one month old, but the utmost care should be observed to be sure that it is fresh from the silo. For this reason very young calves, except in the hands of a very careful feeder, should not be fed silage, as it ferments rapidly when exposed to the air. Care should be used in starting with silage, using only a little at first and gradually increasing the quantity as the animal becomes used to it. Generally there is no danger that the calf will get too much roughage if it is clean and of the proper quality.

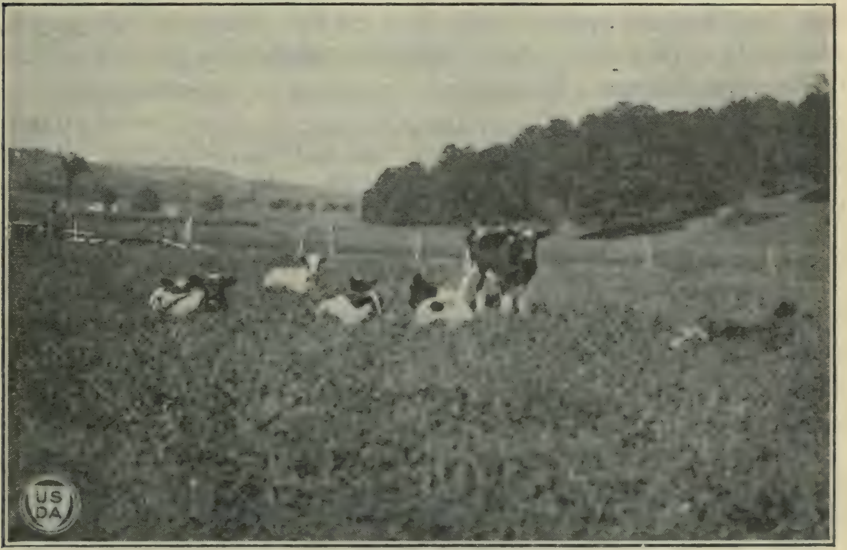

FIG. 2.—Calves on second-growth clover.

If the calf has access to good pasture during the first 6 months it need not receive other roughage. Pastures used in summer should contain plenty of shade. It is not advisable, however, to have a calf under 2 months of age on pasture in the early spring. Good pasturage for calves is shown in Figure 2.

GRAIN FOR CALVES.

Whole milk is "nature's balanced ration" for the calf. When skim or separated milk is fed, other feeds are used to supply the fat which has been removed. Proprietary calf feeds or meals, for feeding with separated milk, have been put on the market. Many of these have merit, but by using the feeds usually found on the farm or in markets near by the farmer can generally mix a grain ration which is as good and costs less.

Wheat bran is a grain which is readily taken by young calves. Inasmuch as one of the essential points is to induce the calf to eat grain as early as possible, bran in many cases is one of the ingredients in the mixture. Corn, a feed very commonly found on the farm, has an excellent physiological effect upon cattle of all ages, and to a great extent may take the place of the fat removed from the milk. It is therefore one of the very best grains to use with skim milk. Experiments in Virginia tend to show that corn fed to calves should be cracked rather than finely ground. Cracked corn and wheat bran therefore should be the basis of the feed mixture. Ground oats are very good for the purpose, but they are not grown on the farm so commonly as corn and in many cases cost much more per unit of feed than corn and bran. The following mixtures are recommended:

(1) Three parts cracked corn and 1 part wheat bran.

(2) Three parts cracked corn, 1 part wheat bran, and 1 part ground oats.

(3) Three parts cracked corn, 1 part wheat bran, 1 part ground oats, and 1 part linseed meal.

(4) Five parts cracked corn, 1 part wheat bran, 1 part ground oats, and 1 part blood meal.

(5) Oats, ground.

When the calf is in its second week it should begin to receive grain, and when one month old it should eat about half a pound a day. After this time the quantity of grain may be gradually increased, feeding the calf all that it will take until 3 pounds a day is reached; this will probably be some time during the third month. Grain when fed with separated milk should never be put into the milk. It is questionable whether the preparation of grain in any way, such as soaking or boiling, is advisable under any circumstances. Grain should be furnished in separate feed boxes placed so that it can not be soiled by the droppings of the calf, but at the same time will be where the calf can get at it readily. There should be no corners in which wet feeds may ferment, and the utmost care should be taken to keep the grain fresh and clean at all times.

MILK SUBSTITUTES.

In dairy herds in which the entire output is sold as whole milk at high prices there is a strong demand for feeds to take the place of the milk fed to the calves. While it is probably not practicable to take calves two days old from the cows and raise them entirely without milk, some skillful feeders have been able to approximate these conditions. The time at which calves can be put on milk substitutes depends upon the same factors as in the use of separated milk, namely, the breed, development, and vigor of the calves, etc. It is hardly safe, as a rule, even with the most vigorous ones, to attempt to put them on milk substitutes alone within three weeks after birth; and with calves below the normal in vigor, some milk for six weeks or more may be necessary to raise them. In supplying a substitute for milk an attempt is usually made to use a liquid which in composition resembles milk as much as possible. The following milk substitutes are among those in use:

BEAN SOUP.

Bean soup for calf feeding is prepared as follows: Parboil the beans in soda and drain the water off, add water and boil the beans until soft, then press through a colander. A quarter of a pound of beans in 4 pints of water constitutes one feed at first. This should be gradually increased until the calf consumes 1 pound of beans at a feed, on the basis of two feeds a day.

ENGLISH PREPARATION NO. 1.

Wheat flour, 1 pound; ground flaxseed,[1] 2 pounds; linseed meal, 1½ pounds. Stir ¼ pound of the mixture into 6 pints of boiling water for one feed (twice a day) at first. Gradually increase until the quantity is doubled.

ENGLISH PREPARATION NO. 2.

Linseed meal, 2 pounds; oatmeal, 2 pounds; ground flaxseed, 1 pound. Mix 1 pound with 7 pints of boiling water, and allow to stand overnight. Next morning take one-half of the mixture, add water enough to make 5 pints, boil for 10 minutes, and add ½ teaspoonful of salt and 2 teaspoonfuls of sugar. This makes one feed for the first few days that the calf is put on this ration and fed twice a day. Gradually increase until quantity is doubled.

HAYWARD'S CALF MEAL.

Prepared and used by H. Hayward at the Pennsylvania Agricultural Experiment Station, State College, Pa.

Flour, 30 pounds; coconut meal, 25 pounds; nutrium or dried skim milk, 20 pounds; linseed meal, 10 pounds; dried blood, 2 pounds. One-half pound of this mixture is stirred into 3 pints of boiling water, and when sufficiently cool constitutes one feed when the calf is fed twice a day. This is the ration at the start; the quantity is gradually increased as with the English preparations.

One of the objections to this mixture is that some of the ingredients are not readily obtained in all sections of the country.

LINDSEY'S CALF MEAL.

Prepared and used by J. B. Lindsey at the Massachusetts Agricultural Experiment Station, Amherst, Mass.:

Ground oat flakes, 22 pounds; flaxseed meal, 10 pounds; flour middlings, 5 pounds; fine corn meal, 11 pounds; prepared blood flour, 1½ pounds; salt, ½ pound. The gruel is prepared in the usual way, by adding a little cold water to the dry meal and then about 5 pints of boiling water for each half pound of meal. The mixture should be allowed to stand until cool, and always warmed to 90° or 100° F. before feeding. The directions for feeding are the same as for Hayward's meal.

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[1] In preparing flaxseed or linseed for calves, it should be boiled with water or very thoroughly scalded. If merely soaked in water (cold or warm) the conditions favor the production of a poison. On the other hand, if it is fed whole or simply crushed, there is no risk of poison.

SKIM-MILK POWDERS.

One pound of powder is mixed with a small quantity of cold water to prevent the formation of lumps, then stirred into 9 pounds of boiling water and fed in the same proportion as milk.

The quantity of this powder available for calf feeding at a cost within the reach of the farmer is limited. First-grade skim-milk powders cost too much to feed to calves. In the manufacture of skim-milk powder, however, a limited quantity of low-grade product is made, not good enough to sell for bakers' or confectioners' use, which usually can be purchased at a price that permits its use in calf feeding. Under present conditions it is questionable whether these powders have wide use in calf feeding.

BELTSVILLE CALF MEAL.

The following mixture has been devised as the result of experience at the experimental farm of the Dairy Division at Beltsville, Md.:

Take 50 parts finely ground corn; 15 parts linseed oil meal; 15 parts finely ground rolled oats; 10 parts dried blood flour; 10 parts skim-milk powder; ½ part salt. Stir up with warm water at the rate of 1 pound of meal to 9 pounds of water. Increase gradually as whole milk is decreased, until at the time the calf is about 50 days old it should be getting only the gruel. At this time 1½ to 2 pounds of the meal mixed with water will constitute a day's feed.

In feeding all-milk substitutes the quantity fed should be substantially the same as when separated or whole milk is fed. If, however, there are indications of scours, the quantity should be reduced. The following may serve as a guide in using milk substitutes for feeding strong, vigorous calves:

First week	Whole milk.
Second week	Whole milk.
Third week	Three parts whole milk, one part gruel.
Fourth week	Three parts whole milk, one part gruel.
Fifth week	Whole milk and gruel, equal parts.
Sixth week	Whole milk one part, gruel three parts.
Seventh week	All gruel.

Milk substitutes lack a great deal of being as satisfactory as either whole or skim milk, and milk has to be very high in price to justify the use of milk substitutes during the first two weeks of the calf's life.

Grain and roughage should be fed with milk substitutes the same as with separated milk.

QUARTERS FOR CALVES.

Small calves should not be bumped and jostled about. An easy way to prevent this is to provide small pens, not less than 4 by 6 feet in size, in each of which a calf may be kept for the first two weeks. The pens should be fitted with feed boxes for grain and racks for hay. After the calf is old enough to run with the others it is placed with them in a larger pen. Stanchions are fixed on one side of this pen to provide for the separate feeding of the calves, so as to insure that each receives its proper share. Racks for hay should also be placed within easy reach of the calves.

Too much emphasis can not be laid upon the necessity of having light, dry quarters for the calves. Bedding always should be abundant and should be changed often, in order that the pen always may be dry. Lack of attention to these matters is very likely to allow the development of the various calf diseases. Good quarters for calves are shown in Figures 1 and 3.

After the calf is a few weeks old, it can stand considerable cold if it is kept dry and has dry quarters. Provision also should be made to allow the calves plenty of exercise. A small paddock or pasture adjoining the calf stables is excellent for this purpose. Except for the very young ones, calves may be let out in the exercise lot for a short period each day when the weather is not too cold or stormy.

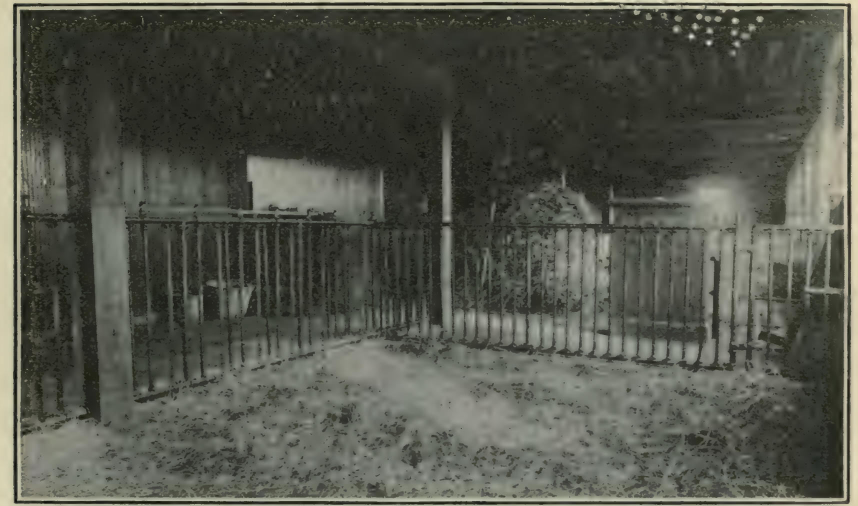

Fig. 3.—Good quarters for calves, well bedded. The metal railing on the left comprises stanchions with feed trough just beyond (shown more clearly in Fig. 1).

STANCHIONS FOR CALVES.

If the calves are kept together in a large pen, it is very difficult to feed them by hand unless they are tied. When they are loose the milk often is spilled, and the larger calves get part of the smaller ones' share. Very simple stanchions may be constructed to prevent losses of milk and insure the equal distribution of the feed. To prevent the calves from sucking one another, they should be kept in the stanchions for some time after feeding.

A calf stanchion may be constructed of cheap or scrap lumber. It is usually 36 to 40 inches high and has a 4-inch space for the calf's neck. A design for a practical stanchion is shown in Figure 4. Figure 5 shows stanchions in use.

PREVENTION OF HORNS.

In the ordinary dairy it is better that cows be without horns, as the danger of their hooking one another is thus prevented. Only in purebred herds, where the appearance of the herd is considered important from a show or sale point of view, is there any justification for allowing horns to grow. It is much easier to prevent the growth of horns than to remove them.

The points that ultimately will develop into horns can be felt as small buttons embedded in the skin. The prevention is easiest if the treatment is applied when the buttons are just large enough to be felt, which is usually between the third and the seventh days. To prevent their development, the hair should be removed from the horn buttons; a stick of caustic potash or soda, wrapped in paper to protect the hands of the operator, is moistened with water and rubbed on each horn button until a raw spot the size of a 10-cent piece is produced. The caustic should not be too moist, for if it runs over on the surrounding skin it will remove the hair and cause unnecessary pain. Immediately after the application the calf should be protected from rain, in order to prevent the caustic from spreading. If the operation is carefully performed the horns will make no growth. If scurs or horn growths appear, it is an indication that the caustic was not properly applied.

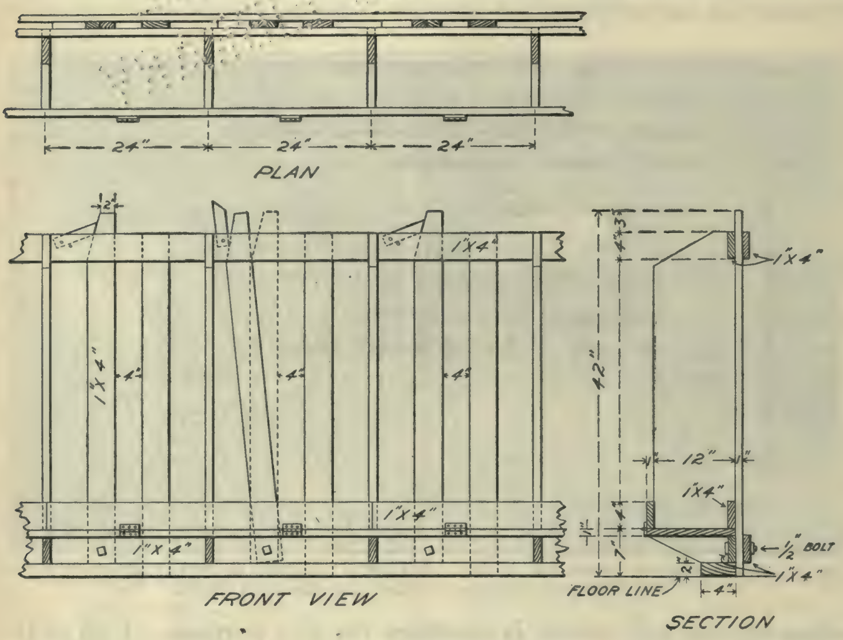

FIG. 4.—Calf stanchion.

Heifer calves a month or more of age may be successfully treated by making a raw ring about the base of the horny growth. However, treating calves at this age takes more time and is more painful.

WATER AND SALT.

Many feeders fail to realize the importance of providing the young calf with plenty of water. It is a mistake to think that because the calf drinks milk it does not need water. After the calf is two weeks old it should have access to plenty of fresh, clean water at all times, and when it is old enough to eat roughage it should have access to salt.

MARKING CALVES FOR IDENTIFICATION.

It is important that each calf be marked plainly so as to permit of easy identification. This is particularly necessary in purebred herds, and should be done in all herds of any considerable size, even if composed of grades.

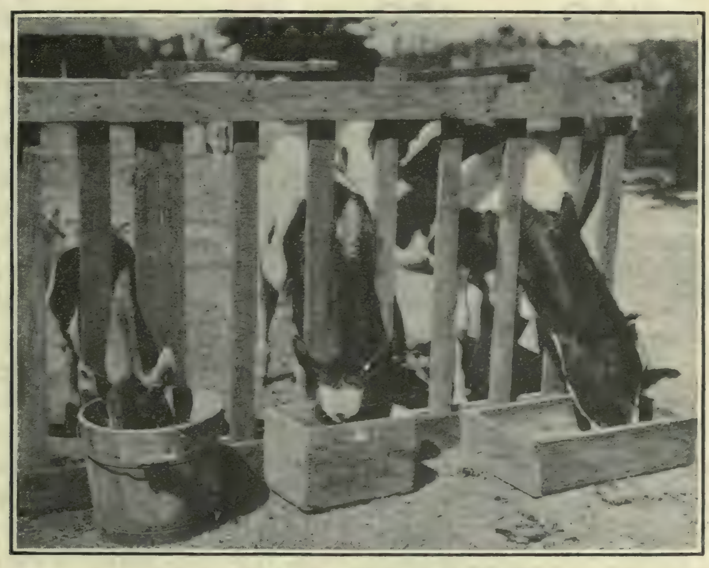

FIG. 5.—Calves eating, showing use of stanchions.

A number of marking systems have been in general use, among which the following are some of the most common: Leather strap around the neck, with brass tag attached; ear tags of various forms; notches and holes in the ears; and tattoo marks in the ears.

The leather strap with tag around the calf's neck is a convenient method of marking. The advantages of this system are that the number may be observed readily and no disfiguration of the animal is necessary. The cost, however, is somewhat higher than that of other systems because of the first cost of the straps and tags and because their renewal is sometimes necessary.

Ear tags of various materials and forms are perhaps the most common means of identification; these tags are inexpensive and easy to attach, but have the disadvantage of being easily torn from the ears.

Marking animals by means of holes and notches in the ear is practiced in many herds, and a number of systems are in use for this purpose. Figure 6 illustrates such a marking system.

The notches are made with a punch specially designed for the purpose. Care should be taken to make them so that they can be readily detected in running the fingers along the edge of the ear. Under no circumstances should they be made with a knife, as the outlines of a small cut made by such an instrument become obliterated or may be confused with the slight natural indentations of the ear as the animal grows older. It is also very difficult to make the cut of the right size with a knife, and if too large the animal is greatly disfigured. This system, while causing a slight disfigurement of the animal, is very simple, and if rightly done the notches are scarcely noticed. A serious disadvantage, however, is that mistakes in marking can not be easily corrected. To illustrate the use of this method the following examples are given: No. 7, two notches on lower edge and one notch on upper edge of left ear; No. 46, one notch on lower edge of right ear, one notch on upper edge of right ear, and two notches on lower edge of left ear; No. 152, one notch in center of left ear, one notch on lower edge of right ear, two notches on upper edge of right ear, and two notches on upper edge of left ear. The following list of numbers illustrates the use of the system:

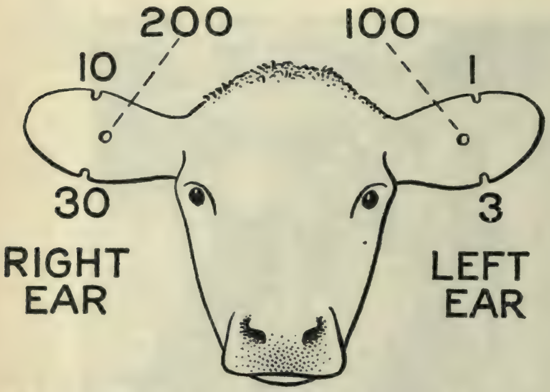

FIG. 6.—Illustration of a notch method of marking calves for identification.

Serial numbers for calves.	Punch numbers to be used in making the combination.	Serial numbers for calves.	Punch numbers to be used in making the combination.
1	1	9	3, 3, 3
2	1, 1	10	10
3	3	50	30, 10, 10
4	3, 1	100	100
5	3, 1, 1	123	100, 10, 10, 3
6	3, 3	234	200, 30, 3, 1
7	3, 3, 1	345	200, 100, 30, 10, 3, 1, 1
8	3, 3, 1, 1	456	200, 200, 30, 10, 10, 3, 3

Sixty-three different numbers, which is far more than enough for most herds, can be made by using combinations in which each different punch position is used only once. These are 1, 3, 4, 10, 11, 13, 14, 30, 31, 33, 34, 40, etc.; 100, 101, 103, etc.; 200, etc.; 300, etc.

The identification of an animal by means of tattoo marks in the ears has become quite common in recent years. This system of marking animals has the advantage of not disfiguring the animal, and if properly applied the tattoo is permanent, so that the chance of losing the identity of the animal by the loss of the tag is greatly lessened. On the other hand, it requires close inspection to distinguish the marks in the ears.

CALF DISEASES.

SCOURS FROM INDIGESTION.

Diarrhea, or scours, is probably the most common disease of calves. Great care must be taken at all times to prevent this condition, as it always hinders the growth and development of the animal and, in addition, is often hard to cure. This disease is the result of disturbance of the digestive apparatus of the calf and may be caused in a number of ways, the more important of which are the following: Irregular feeding, overfeeding, sudden change of feed, fermented feeds, feeding dirty or sour milk or milk of diseased cows, use of dirty milk pails or feed boxes, and damp, dirty stables. As soon as scours is discovered it is best to separate the affected calf from the others and carefully disinfect the pen. The feed should be reduced immediately at least one-half, milk pails cleaned and sterilized, feed boxes cleaned and disinfected, and any other causes mentioned above eliminated.

A number of preparations are used to treat this disease, a few of the more common of which are blood meal, a teaspoonful at a feed; white of egg; limewater, etc. A dose of four drops of formalin to each quart of milk has been used to advantage, and a drench of three ounces of castor oil, followed by a teaspoonful of a mixture of one part salol and two of subnitrate of bismuth also is recommended.

WHITE SCOURS.

White scours, or infectious dysentery of the calf, generally affects a number of calves in a lot, and first appears shortly after birth as a diarrhea with light-colored, offensive droppings. During the course of this disease the calf wants to sleep all the time and can not be induced to suck or drink. It is also very much weakened by the disease and usually dies within three or four days. So far as the department knows, there is no specific method of curing the disease. Manufacturers of biological products, however, are now selling a serum which they claim to be effective in both prevention and cure.

Prevention consists in the use of sanitary precautions, such as clean, dry, and disinfected pens for calving, and treatment of the newborn calf by tying the navel of the calf near the body with a small cotton string immediately after birth, cutting the navel cord just below the tie, and applying tincture of iodin or other good disinfectant to the cord. With such precautions, danger from the disease is much lessened. Nevertheless, if a bad outbreak occurs it may cause the loss of a season's crop of calves, and a competent veterinarian should be consulted.

FEEDING AND MANAGEMENT OF YOUNG DAIRY STOCK.

FEEDING FROM SIX MONTHS TO ONE YEAR OF AGE.

As has been previously stated, it is a common practice among dairymen to feed skim milk until the calf is approximately 6 months of age. Usually the time of weaning depends upon the availability and cost of milk.

When milk is fed in abundance it furnishes the greater part of the protein necessary for the growth of the animal.[2] If no milk is fed it becomes necessary for the protein to be provided from some other source. Probably this can be done most economically by the use of some legume, such as alfalfa, clover, soy bean, or cowpea hay. When hay of this sort is not available it is necessary to provide the bulk of the protein in a grain mixture. In either case, plenty of roughage should be supplied to the growing heifer at all times. During summer, when good pasture is available (see Fig. 7), the heifer needs no supplementary feed, although a little hay and grain are sometimes advisable late in the season to insure steady growth.

Part of the roughage should be silage, if it is available. A heifer six months to one year of age will consume from 5 to 15 pounds of silage a day. The grain mixture used may be the same as mentioned for calf feeding (see p. 8), any one of Nos. 1, 2, 4, and 5, together with all the alfalfa, clover, or cowpea hay that the heifer will eat. In case no leguminous hay such as that just mentioned can be obtained, No. 3 is advised, because it contains more protein. Another excellent grain mixture, to be used when such hay is lacking, is composed of 2 parts of corn meal, 2 parts of linseed meal, and 1 part of bran.

The quantity of grain to be fed depends very largely upon the individual animal's growth and condition, as well as upon the price of the grain. Some feeders desire a rapid growth of the young animal, and for this reason feed heavily with grain, while others are satisfied with a slow growth and try to carry their young stock largely on roughage. Either extreme is unwise and a medium course between the two is advisable. A safe rule to follow is to feed 1 pound of grain for the first hundredweight of the heifer and ½ pound for each additional hundredweight.

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[2] Protein is the nitrogenous part of feed and body structure. It is indispensable for making milk and muscle and for growth. The curd of milk, the white of egg, and lean meat are typical forms of animal protein.

FEEDING FROM ONE TO TWO YEARS OF AGE.

After the heifer reaches one year of age, the following rations are suggested: Corn meal, fed according to the rule just mentioned, together with all the alfalfa, clover, or cowpea hay that the animal will consume. If no leguminous hay is available, grain composed of 2 parts of corn meal, 1 of bran, and 1 of linseed meal, gluten meal, or cottonseed meal, and 10 to 20 pounds of silage, together with all the dry roughage that the animal can consume, will be found to be adequate. Under ordinary circumstances a gain of at least a pound a day from the time of weaning to the time of first calving is a good average for a dairy heifer.

FIG. 7.—Heifers on pasture.

AGE TO BREED.

Ordinarily it is planned to have the heifer enter the milking herd between 24 and 30 months of age. No arbitrary time can be set, as this depends upon several factors, such as the size and condition of the animal and the breed to which she belongs. Undersized and ill-conditioned animals should be allowed more time to complete their growth and to improve in condition before entering upon the strain of calving and the ensuing lactation period. It is very important that the heifer make a good growth before she is bred, because after that time she will make little body growth until after she has completed her first lactation period.

If heifers are bred to a heavy bull, it is advisable to use a breeding rack in order to avoid danger of permanent injury to the heifer from the weight of the bull. Such a rack is inexpensive and easily constructed.

HANDLING YOUNG HEIFERS.

Young heifers should be handled as much as possible in order that they may not be shy when they enter the herd. A good plan is to bring the "springing" heifer up to the barn some time before she is due to calve and get her accustomed to the halter and stanchion and to being handled. A little care in this way often prevents considerable trouble after calving, and usually insures a gentle cow.

FALL CALVING ADVISABLE.

From the standpoint of the dairyman who raises his calves, fall calving is desirable under most conditions. Under this system the calf receives milk for the first few months of its life, and at the time when it becomes necessary to wean it a succulent feed in the form of pasturage is available. As a result the calf usually makes uninterrupted gains at a minimum cost. Fall calving has the additional advantage that the bulk of the milk following it is produced at the time when prices are best and when it is easiest to maintain a steady flow, and the calves are of the right age so that with careful management they may be bred to freshen in the fall or winter for the first time.

THE YOUNG BULL.

The bull calf should be separated from the heifers at about 4 months of age. His treatment and feeding should be identical with those of the heifer except that to get maximum growth he should receive a little larger quantity of grain. If properly handled, the young bull is ready for light service at the age of from 10 months to a year. Too much service before he is 2 years of age will do him permanent injury. It is important that he be properly trained to halter, as this will make him much easier to handle when he is old. At 6 months of age a ring should be put in his nose.

The horns of bull as well as heifer calves may be removed at an early age, as described above (page 12). Where this has not been done, it is the practice of some breeders to remove the bull's horns after he reaches maturity, as it is asserted that this tends to reduce his fighting spirit.

It should always be kept in mind that exercise is essential to the proper development of a young bull and to the health and vigor of a mature one. A small paddock, with a shed for protection against stormy and windy weather, will give him room for plenty of exercise and keep him in good condition. Two bulls, if dehorned, may be kept together to advantage, as they exercise each other. Precautions should be taken to see that each receives his proper portion of feed.

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FARMERS' BULLETIN No. 1337

DISEASES OF POULTRY

1862 1889

CHICKENS, turkeys, ducks, geese, and pigeons are susceptible to many diseases, some of which are highly infectious. Disease germs pass rapidly from bird to bird of the flock, and may be carried by one means or another to neighboring flocks, producing extensive outbreaks, or epizootics.

Certain diseases respond favorably to treatment. Others resist all efforts at treatment and cause very heavy losses.

Preventive measures properly applied offer the surest means of controlling diseases of domesticated birds.

It is necessary that the poultry owner be enlightened as to the characteristics of the more important diseases in order that he may intelligently use the most approved methods of combating them.

Sanitary and other measures which have been found successful in the control of poultry diseases may, if properly applied, materially reduce the great annual losses in flocks.

Washington, D. C. Issued July, 1923

DISEASES OF POULTRY.[1]

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SUSCEPTIBILITY TO DISEASE.

DOMESTIC BIRDS are subject to a considerable number of diseases, some of which spread rapidly through the flock and cause a high mortality. They may also be infested by various kinds of parasites, some of which live on the surface of the body and others in the crop, stomach, or intestines. These parasites are injurious because they take a part of the nourishment which should be used by the bird to put on flesh or to produce eggs, and also because by their movements and their biting they cause irritation and inflammation of the parts which they attack.

The contagious diseases which are caused by germs and the weakness and loss of flesh caused by the larger parasites, to which reference has just been made, are the most important conditions which the poultryman has to consider in the endeavor to keep his birds healthy. These germs and parasites should be kept out of the flock by suitable preventive measures, because disease may be avoided much more easily and cheaply than it can be cured. The aim in studying the diseases of poultry is, therefore, to learn how to prevent the diseases as well as how to cure them.

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[1] This bulletin supersedes Farmers' Bulletin 957, Important Poultry Diseases.

HOW TO PREVENT DISEASE.

Precautionary methods will do much to keep birds free from disease, since infections gain entrance to the flock through the introduction of new birds from infected flocks, exposure at poultry shows, or contact with fowls which are diseased. Infection may also be carried to premises on the shoes of man or feet of animals. Free-flying birds are apparently responsible for the spread of disease in some cases. Poultry keepers should quarantine newly procured fowls or show birds for two to four weeks, in order to allow symptoms of any disease which may be carried to develop.

The greater the number of birds kept upon any farm or plot of ground and the more they are crowded together the greater is the danger from contagion and parasites and the more important are the measures of prevention and eradication.

HOW TO CONTROL DISEASE.

As a rule, when a bird becomes sick the best policy is to kill it, for the reason that it may be affected by a contagious disease which, before it is recognized, may spread to many others in the flock. Also, if the poultry owner attempts to treat such birds, there is great danger of carrying infection from the sick to the healthy in handling or feeding. If a disease becomes established in the flock, however, a line of treatment should be undertaken when possible. In some diseases, such as cholera and the choleralike diseases, fowl typhoid, tuberculosis, and aspergillosis, treatment of affected birds is of little value and preventive sanitary measures must be depended on to keep infection as low as possible.

In controlling outbreaks of infectious diseases the first effort should be to separate the sick from the healthy birds as soon as symptoms become noticeable. The droppings should be removed from the houses daily and placed where the fowls will not have access to them. The houses and all feeding and drinking utensils should be frequently cleaned and disinfected. The use of permanganate of potash in the drinking water serves to prevent the spread of infection by means of the water, which otherwise is likely to be contaminated by discharges from diseased birds. The proportion is one-third teaspoon of permanganate to the gallon of drinking water. It is also advisable to give the entire flock a dose of Epsom salt in the proportion of one-half teaspoon to the adult fowl. The salt may be mixed in a sufficient quantity of mash for one feeding.

DISINFECTANTS AND THEIR APPLICATION.

Good disinfectants destroy the germs of contagious diseases, the external parasites, such as lice and mites, and in some cases the eggs of parasitic worms. The disinfectants should be thoroughly applied to the interior of the houses, worked into all the cracks and crevices, spread over the ceiling and the floor, the roosts, dropping boards, and nest boxes. At the same time the feeding and drinking troughs should be disinfected by pouring boiling water into them and afterwards drying them in the sun. Disinfectants are most easily applied to the walls and ceilings with a spray pump or with a brush. As it is difficult to keep them from coming into contact with the face and hands, the more harmless of these mixtures should generally be used. Ordinary limewash made from freshly slaked lime is excellent, and its properties are well known. In the case of an actual outbreak of virulent disease it is well to add to the limewash 6 ounces of crude carbolic acid to each gallon to increase its activity as a disinfectant.

The kerosene emulsion, which is frequently used to destroy mites, may readily be converted into a disinfectant. To make the emulsion, shave half a pound of hard laundry soap into half a gallon of soft water and boil the mixture until all the soap is dissolved, then remove it to a safe distance from the fire and stir into it at once, while still hot, 2 gallons of kerosene. This makes a thick, creamy emulsion or stock mixture. When it is to be used for killing mites in the houses, 1 quart of this emulsion is mixed with 10 quarts of water. When it is to be used as a disinfectant, stir well, then add 1 pint of crude carbolic acid or crude cresol, and again stir until all is well mixed.

The compound solution of cresol is one of the best disinfectants and may be purchased ready for use. It contains 50 per cent of cresol, and 1 pint of it added to 10 quarts of soft water makes a solution of the proper strength to apply to the houses or to spray over the ground. A 5 per cent solution of carbolic acid (1 pint of carbolic acid to 10 quarts of water) is about equally efficacious. The choice between the two is a matter of convenience.

SIMPLE CATARRH (COLDS).

Simple catarrh is a mild inflammation of the nasal passages, and is common to all kinds of domesticated birds.

Cause.—No definite cause may be assigned to this affection. It has been asserted that weak or improperly nourished birds are more likely to be attacked than strong, vigorous, well-nourished individuals. Exposure to unfavorable conditions, in which rain, dampness, and cold drafts tend to lessen the resistance of the mucous membranes of the nostrils to the various organisms normally present in this region, has been held to be the primary contributing cause.

Symptoms.—The affected bird is more or less dull in appearance, according to the severity of the attack. The appetite is diminished, breathing becomes difficult, and a watery discharge from one or both nostrils is early in evidence. This discharge may disappear in two to four days, or it may take on a viscid consistency, closing the nasal openings and necessitating breathing through the mouth.

Treatment.—As the disease is of short duration, it is usually necessary only to place the patient under more favorable conditions to bring about recovery. In the more severe cases the nostrils should be washed out twice daily with boric acid in 3 per cent solution, or permanganate of potash, 1 dram (about a teaspoonful) to a pint of water.

CONTAGIOUS CATARRH (ROUP).

Contagious catarrh, or roup, attacks principally the membranes lining the eye, the sacs below the eye (infraorbital sinuses), the nostrils, and the windpipe (Fig. 1).

Cause.—The nature of the microbe which constitutes the virus of roup is not known. The contagion is generally brought into the poultry yard by infected birds. Sometimes they are birds which are purchased from other flocks in which the disease exists; sometimes they are birds of the home flock which have been in exhibitions and there exposed to sick fowls; and sometimes they are wild birds or pigeons which fly from one poultry yard to another.

The saliva and the discharge which escapes from the nostrils carry the contagion and soon contaminate the drinking water and feeding troughs, so that all the fowls are exposed to infection. Even the flocks in adjoining yards are infected by the particles of mucus projected into the air when sneezing, or by the contagion carried on the feet of persons, animals, or small birds that pass from one yard to another. Exposure to cold, dampness, and drafts aids in the development of roup.

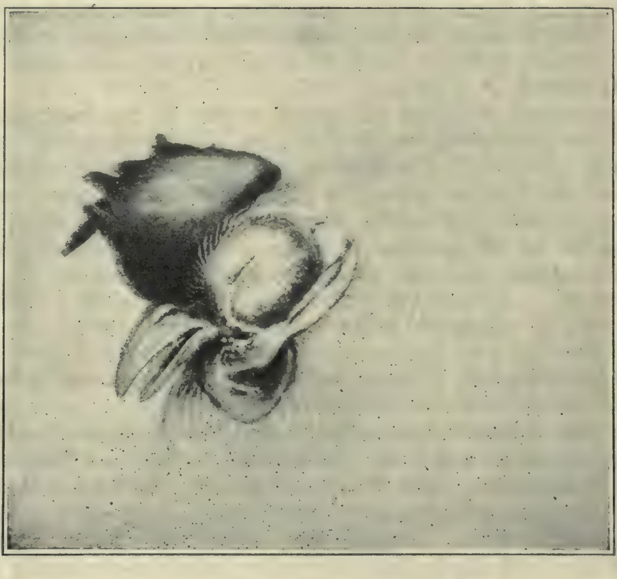

FIG. 1.—Head of fowl affected with contagious catarrh (roup), showing swelling of the eye.

Symptoms.—The symptoms first seen are very similar to those of an ordinary cold, but there is more fever, dullness, and prostration. The discharge from the nasal openings is at first thin and watery, but in two or three days it becomes thick and has an offensive odor. The inflammation, which begins in the nasal passages, soon extends to the eyes and to the spaces immediately below the eyeballs, causing the formation of swellings which may reach the size of a hickory nut. The eyelids are swollen, held closed much of the time, and may be glued together by the accumulated secretion. The closing of the eyes prevents the badly affected birds from finding food. The accumulation of mucus in the nostrils completely obstructs these passages so that the beak must be kept open to permit the bird to breathe. The obstruction of the windpipe and of the smaller air tubes causes loud breathing sounds and difficult respiration. In the severe and advanced cases the birds sit in a somnolent or semiconscious condition, unable to see or to eat; their strength is rapidly exhausted, and many of them die within a week or 10 days. Some of the affected individuals recover, but others remain weak and have a chronic form of the disease for months, during which time they continue to disseminate the contagion.

This disease is distinguished from diphtheria (chicken pox) by the absence of the thick, tough, and very adherent cheesy exudates in the mouth and throat which are characteristic of the latter disease. Sometimes there may be a deposit of yellowish material on the walls of the mouth and throat, but it is easily broken up and removed. There are no warts on the comb, face, or wattles.

Treatment.—Medical treatment may be very successful if properly applied. The sick birds should be removed from the flock and put in a warm, dry, well-ventilated room which is free from drafts. The affected mucous membranes of the nostrils and mouth should then be treated by applying antiseptic solutions. The best method is to use a good spraying apparatus, but, lacking this, a small syringe, an oil can, or even a medicine dropper can be made to answer the purpose, or the bird's head may be plunged into a basin or bowl of the solution and held there a few seconds, but not long enough to cause suffocation.

The antiseptics most suitable for such treatment are: Boric acid 1 ounce, water 1 quart; or permanganate of potash 1 dram, water 1 pint; or peroxid of hydrogen 1 ounce, water 3 ounces. Where the inflammation has progressed to the eye, excellent results have followed the use of argyrol. One or two drops of a 15 per cent solution are introduced between the eyelids twice daily for a period of several days.

Before applying these substances it is well to wash the eyes and mouth with warm water containing 1 teaspoon of common salt to a quart, using a pledget of absorbent cotton and rubbing gently, while at the same time pressing and massaging about the nostrils and under the eyes to loosen the accumulated secretion. If there is a swelling under the eye, it should be carefully opened with a sharp, clean knife, all the secretion removed, and the cavity washed with one of the above-mentioned solutions. A pledget of cotton moistened with the solution may be left in the opening for an hour or two.

The houses should be kept clean and dry and occasionally disinfected. Also dissolve one-third teaspoon of permanganate of potash in each gallon of drinking water. If the disease proves to be of a severe type, it is often better to kill the affected birds. This radical method avoids the retention of birds which may harbor the contagion and cause the development of subsequent outbreaks.

CHICKEN POX (DIPHTHERIA).

Chicken pox and diphtheria were originally thought to be separate diseases. It was discovered later that the virus which causes the formation of warts or pox nodules on the head, typical of chicken pox, also causes the cheesy patches in the mouth and eyes which are characteristic of diphtheria. Since the symptoms of chicken pox and diphtheria are but external and internal manifestations, respectively, of the same disease, the two conditions are now combined and described as chicken pox. Chickens and pigeons are most frequently affected, but turkeys and birds generally are susceptible.

Cause.—Chicken pox is caused by a virus which passes through laboratory filters and can not be seen under the microscope. The disease is strictly infectious and never develops as a result of exposure to dampness and drafts alone, although these conditions favor its spread and tend to increase its malignancy. The contagion is introduced and disseminated in a flock in the same manner as described for roup. It is quite probable that biting insects, such as mites, also spread infection through inoculation from sick to healthy birds.

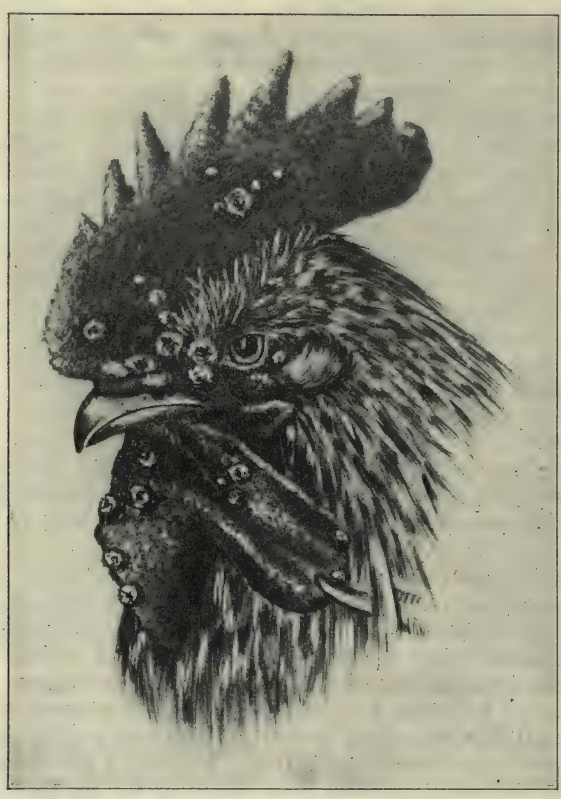

FIG. 2.—Chicken-pox nodules on comb, on wattles, and near corner of mouth. (After Hutÿra and Marek.)

Symptoms.—The disease has the general symptoms of roup but is distinguished from the latter by an eruption of pox nodules on the head and by the presence in the mouth, throat, and eyes of tough, cheesy patches which are firmly attached to the tissues beneath them. (Figs. 2 and 3.)

The eruption appears as round, oblong, or irregularly shaped nodules from the size of a pinhead to that of a pea or a hazelnut. It is seen especially about the beak and nostrils and on the comb, the eyelids, the wattles, and the ear lobes. In some individuals, and particularly in pigeons, the eruption is more generalized and is found on the skin of other parts of the body, as the neck, under the wings, on the rump, and about the vent. Here the nodules may become larger than on the head. The nodules begin as small red or reddish-gray growths with a shiny surface and gradually enlarge, while the color changes to a yellowish, brownish, or dark brown, and the surface dries and becomes shriveled, uneven, and warty in appearance. Owing to the number of nodules and the extension of the inflammation, large patches of skin become thickened and covered with hard, dry crusts, closing the nasal openings or the eyelids, and making it difficult even to open the beak.

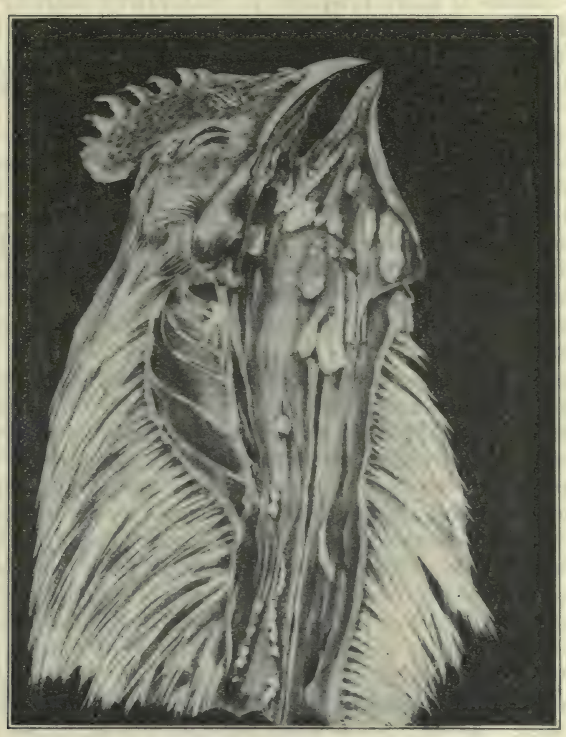

FIG. 3.—Fowl diphtheria. Neck slit open to show diphtheritic patches in mouth and esophagus. (After Rátz.)

The severity of the disease depends a good deal upon the extent of the internal diphtheritic deposits. These are at first thin, yellowish, or whitish in color, and gradually become thicker, firmer, and more adherent, so that considerable force is required to remove them. The mucous membrane beneath the deposit, when the latter is removed, is found to be inflamed, ulcerated, and bleeding, but it is soon covered by a new deposit. This exudate is called a false membrane, and when it is situated where the breathed air passes over it, it dries, becomes uneven and fissured, and its color changes to a dark brown. With pigeons the exudate is more friable and easily removed, and the mucous membrane beneath it is reddened but not ulcerated.

While the false membranes over the parts first affected are becoming thicker, the inflammation extends to the adjoining surfaces, and new diphtheritic centers develop, uniting with one another until the cheeks, tongue, palate, throat, and inside of the nostrils are covered. Very often the inflammation extends from the nostrils to the eyes, and sometimes it penetrates the air tubes to the lungs, or the gullet to the crop. When false membranes form in the gullet, crop, and intestines there is a rapid aggravation of the symptoms, an intense diarrhea, and the escape of blood with the droppings. This type of the disease is more frequent in waterfowl than in other birds. Some fowls in a flock are resistant, and after a few days of illness rapidly recover. Others remain dull, weak, and thin in flesh, and may have more or less catarrh and difficulty of breathing for a long time.

The period between exposure to the contagion and the appearance of the first symptoms varies from 3 to 15 days. The duration of the disease varies from two or three days to as many weeks in the acute cases, while the chronic form may continue for several months.

Treatment.—The treatment of fowls severely affected with diphtheria requires much time and patience, and as a rule does not pay. It is often better to kill the birds, bury or burn their carcasses, disinfect the poultry houses, and in that way eradicate the contagion as soon as possible.

If it is decided to treat the sick birds they should be removed from the flock and put into a comfortable, well-ventilated room that may be easily disinfected. Make a solution by dissolving 2 drams of common salt in a quart of warm water, and with a soft brush or a pledget of absorbent cotton dipped in this solution gently brush or rub the false membranes until they are disintegrated and loosened from the underlying tissues. Sometimes it is necessary to scrape them off with a spoon or knife, but it must be done carefully, so that bleeding will not be caused or the sensitive tissues injured. After the false membranes are removed, wet a pledget of absorbent cotton in tincture of iodin or in a 5 per cent solution of carbolic acid and apply it for a minute or two to the diseased surface. Another solution which may be used is made by dissolving 1 dram of permanganate of potash in a pint of water. A very good solution consists of 1½ ounces of boric acid and 1 ounce of powdered borax (borate of soda) dissolved in 1 quart of water and applied warm. The two last-mentioned solutions may be used to wash the eyes or may be injected into the nostrils. Argyrol may also be used as recommended in contagious catarrh. If large swellings appear beneath the eyes they should be opened with a clean, sharp knife, the contents of the cavity removed, and the space frequently washed with the boric-acid-borax or permanganate solution mentioned above.

The external lesions of this disease may be treated successfully by simple local applications. The crusts on the nodules are softened with carbolated ointment, glycerin, or oil, and after an hour or two removed by washing with warm water containing a little soap. The denuded tissue is then treated with a 5 per cent solution of carbolic acid or with tincture of iodin.

As this disease is contagious, the houses, drinking vessels, and feed troughs should be kept disinfected during the outbreak and for several days after all the birds have apparently recovered. The drinking water is made antiseptic by dissolving one-third teaspoon of permanganate of potash in each gallon.

Chicken-pox vaccine is used for the prevention of the disease. Its results are variable. In some cases it appears to prevent or lessen the severity of outbreaks, while in others no benefit seems to be derived from its use.

WHITE DIARRHEA OF CHICKS.

White diarrhea is a commonly used term which covers the various diseases of chicks from the time of hatching until the birds are approximately one month old. It merely indicates a common symptom, a whitish diarrhea, which is usually observed in sick chicks, no matter what the specific nature of the disease may be.

Cause.—There are four important infectious diseases of fowls which affect baby chicks and induce a whitish diarrhea. These are *Bacterium pullorum* infection, coccidiosis, aspergillosis or brooder pneumonia, and cholera. It is necessary that these diseases be treated separately, as their causes, modes of infection, treatment, and the methods for their control differ. They are described under the foregoing names elsewhere in this bulletin. Other conditions, such as faulty regulation of brooder heat and feeding, may cause symptoms of white diarrhea.

Symptoms.—The symptoms in the different forms of white diarrhea of chicks are quite similar and will be given here in order to make unnecessary their repetition under each of the diseases referred to above.

The form of white diarrhea caused by *Bacterium pullorum* infection is observed in chicks from the time of hatching until they are three weeks old. The other three forms of the disease may occur during the first three weeks or later. The chicks may die suddenly after having shown but slight symptoms for a short time. Generally, however, there is first observed a disposition to huddle together and to remain under the hover or under the hen more than young chicks should. Very soon they appear listless, stupid, sleepy, and indifferent to what is going on about them. They stand in one position or sit still with the eyes closed, and the few efforts which they make to pick up feed appear mechanical and unsuccessful. Their plumage loses its luster, the wings droop or project slightly from the body, and the characteristic diarrhea soon appears. The droppings may be white and creamy, mucilaginous and glairy, or they may be mixed with a brownish material. In acute coccidial white diarrhea the droppings are frequently bloody. Often the sticky excrement adheres to the down about the vent, dries, and continues to accumulate until it completely covers and plugs the opening. This condition, known as "pasting up behind," unless soon relieved will bring about the early death of the chick. Many of the diseased chicks chirp or peep almost constantly, and when attempting to void the excrement they may give utterance to a shrill cry, as if the effort brought on paroxysms of pain. As death approaches, the breathing becomes labored and the abdomen heaves with each breath. Toward the last the strength is completely exhausted and the chick sits constantly or lies on the side with out-stretched wings until it dies (Fig. 4). The most prominent and characteristic symptoms in nearly all cases are the white, diarrheal discharges and the rapid wasting away of the affected birds. When infection is present, the losses vary from 50 to 80 per cent of the chicks hatched. Sometimes it is impossible to raise any of them.

Post-mortem appearance.—Post-mortem examination reveals an unabsorbed yolk in the majority of cases. In white diarrhea caused by *Bacterium pullorum* the liver may have an ocher color and areas of congestion. The lungs may show small necrotic spots. In coccidial white diarrhea the ceca or blind pouches of the intestine are usually distended with necrotic or bloody material. In aspergillar white diarrhea the lungs and air sacs are the seat of moldy growths.

Treatment.—Medical treatment of affected chicks is impracticable, except in the coccidial form, as it has very little effect on the course of the disease. The birds may be given sour milk or buttermilk to drink. One-third teaspoon of crude catechu added to a gallon of drinking water is very effective in the coccidial form of white diarrhea.

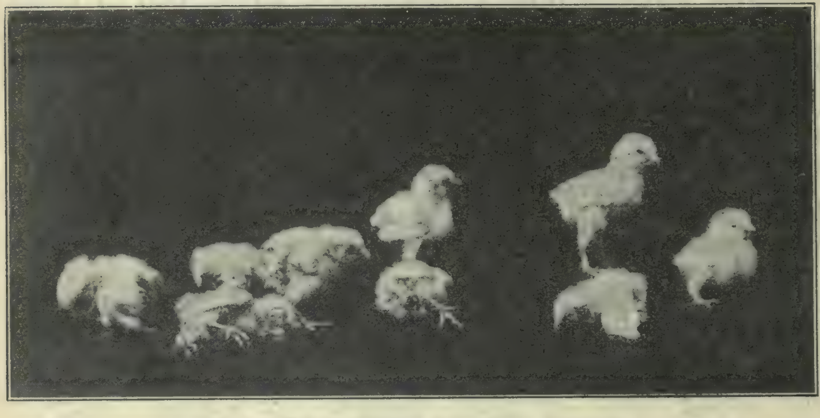

FIG. 4.—Chicks affected with white diarrhea.

For further information on the above-mentioned forms of white diarrhea the reader is referred to the portions of this bulletin dealing with *Bacterium pullorum* infection, coccidiosis, brooder pneumonia, and cholera.

BACTERIUM PULLORUM INFECTION OF FOWLS AND CHICKS.

The microorganism known as *Bacterium pullorum* causes a disease in hens which is generally confined to the ovary. This infection is widespread in the United States and is responsible for enormous losses through its spread by means of the egg to baby chicks, causing "white diarrhea."

Cause.—Chicks which recover from bacillary white diarrhea frequently retain the causative organism, *Bacterium pullorum*, in their bodies, where it later localizes in the active ovary. The disease may be contracted also by feeding with fowls that harbor the organism or by eating infected eggs. In some cases from 50 to 70 per cent of a flock of hens may be affected. Many of the eggs laid by these hens carry the microorganism, and chicks hatched from them spread the disease to others of the brood. Chicks are highly susceptible to infection during the first 48 hours of life, but are practically insusceptible after the third day. Nearly all the exposed chicks become infected, and the death rate may reach 100 per cent.

Another source of infection is through incubators and brooders which have previously held diseased chicks. Day-old chicks from infected flocks may carry infection to other points and contaminate brooders or infect other flocks.

Symptoms.—In acute outbreaks or in experimental infection the hen becomes droopy, the feathers ruffed, the comb and wattles pale, and the head drawn back. There is loss of appetite, and diarrhea is often in evidence. Death follows in from one to several days. In the ordinary form of the disease, however, no external symptoms are observed, and it is only through the presence of white diarrhea in the chicks or the detection of diseased ovaries in slaughtered hens that attention is directed to the presence of the disease in a flock.

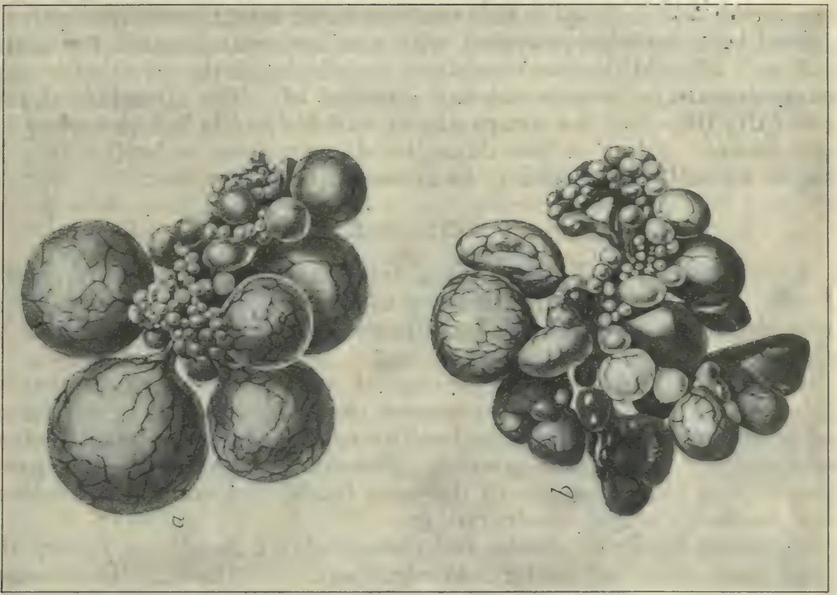

FIG. 5.—Normal ovary of fowl (left) and ovary affected with *Bacterium pullorum* (right). (After Rettger.)

In baby chicks infected in the egg, symptoms appear immediately after hatching or in a day or so. Chicks which contract the disease after hatching show symptoms in from 4 to 10 days later. Deaths occur from the time of hatching until about three weeks later, when the brood is practically wiped out. For symptoms in chicks see White diarrhea, page 9.

Post-mortem appearance.—The ovary presents a characteristic appearance. The partially or wholly developed yolks are angular in outline, shrunken, hard, and discolored to a dark-brown or greenish color (Fig. 5). At times yolks containing dark fluid are present.

The presence of the disease in a flock may be detected by post-mortem examination, by laboratory methods, or by other special tests.

Prevention.—The nature of the affection renders treatment futile. Flocks which harbor the infection should not be used for breeding purposes. The cycle of infection established by the hen, the egg, the recovered baby chick, and the pullet indicates that it is not advisable to save for breeders any chicks which have been exposed to an outbreak of white diarrhea. Where the value of the breed makes its perpetuation desirable, careful incubation may result in the raising of a clean brood of chicks from an infected flock. The trays of the incubator are divided, one or two days before hatching time, into compartments large enough for from 5 to 10 chicks, as the owner may decide. These trays are so constructed as to prevent the exposure of chicks in one compartment to those in another. The birds should be kept isolated in this manner for at least three days or transferred to a brooder provided with similar arrangements for segregation. Should disease break out the chicks in the particular compartment are to be removed and disposed of. The attendant should carefully disinfect the compartment and his hands before caring for the others. After a few days the danger from infection is very slight and all the brood may be allowed to run together.

COCCIDIOSIS.

Coccidiosis is a disease of the intestine and affects all domestic birds. It is especially destructive to chicks up to 2 months old and represents one of the conditions known as " white diarrhea " in baby chicks.

Cause.—A protozoan organism of microscopic size known as *Eimeria* (*Coccidium*) *avium* causes the disease. The transmission of infection from diseased to healthy birds occurs by contamination of the feed, water, and ground. The coccidia multiply with great rapidity in the intestines of diseased birds, and enormous numbers are discharged with the droppings.

Symptoms.—Baby chicks and those under 2 months old show the symptoms described under " White diarrhea " (p. 9). The disease runs a rapid course, and the losses may reach 75 per cent of the brood.

Adult fowls have considerable powers of resistance to this parasite, and the disease with them is more frequently seen in a chronic form. The symptoms are dullness, weakness, sleepiness, diarrhea, and loss of weight, although the birds retain their appetites for a considerable time. In many cases the only symptoms are diarrhea with loss of weight and after a time apparent recovery, though the organisms continue to multiply in the intestine and to be spread with the droppings for several months afterwards. Fowls affected in this manner may die suddenly without previously showing any serious symptoms. Young chicks frequently void bloody droppings, and the bowel contents are bloody.

Pigeons are affected with a more acute type of this disease in which the symptoms appear only a short time before death. Generally, however, they are dull and sleepy for a day or two, and sometimes they have a chronic form, characterized by diarrhea and loss of weight.

Geese with coccidiosis of the kidneys lose flesh rapidly without apparent cause and become very weak and almost unable to walk. They remain quiet most of the time, with the belly resting upon the ground. Some of them lie on their backs with their feet widely separated; and if placed upon their feet, take a few steps, fall, and resume their former position. In all such cases the birds lose their appetites and become progressively weaker until they die.

Treatment.—Put one-third teaspoon of crude catechu in each gallon of the water given the birds to drink. Permanganate of potash, one-third teaspoon to the gallon of drinking water, is quite effective as a substitute. Also feed sour milk or buttermilk. Treatment should be continued until signs of disease disappear from the flock.

Prevention.—As the coccidia are brought on to the premises with birds or with eggs for hatching obtained from infected birds, or by pigeons flying from place to place, the necessary precautions should be observed to guard against such channels of infection. Fowls and eggs should be obtained only from flocks known to be healthy, and pigeons should be excluded from the poultry yard.

This form of contagion is very difficult to destroy, and the most active disinfectants should be used in the houses and yards. A mixture containing 5 per cent of compound solution of cresol is not too strong. The bodies of the birds which die should be burned.

ASPERGILLOSIS (BROODER PNEUMONIA).

Aspergillosis is a fungus disease of the lungs and air sacs which may affect any of the domestic birds. It often causes heavy losses in baby chicks and is then known as brooder pneumonia.

Cause.—The causative agent is the common green mold, *Aspergillus fumigatus*, which grows on vegetables and other kinds of matter. Warmth and moisture favor its development. When moldy hay, straw, or chaff is given to the fowls to scratch in, or moldy grain is fed, the spores of the fungus are inhaled by the birds. The filaments of the mold are capable of passing through the eggshells and it is believed that some outbreaks in brooder chicks may be due to infected eggs which have been exposed to moldy material.

Symptoms.—This disease may be limited to a single bird or it may affect a large number, as in brooder pneumonia. When the air tubes or lungs are attacked, the first symptom is a slight catarrh, with accelerated breathing. Soon the swellings obstruct the passage of air and there is a rattling or croupy sound, heard chiefly during expiration. The affected birds mope, separate themselves from the remainder of the flock, or remain in a sitting posture; if made to move it is seen that they are weak and scarcely able to walk, and if they try to run they soon fall from exhaustion. The difficulty of breathing increases rapidly; they gasp for breath and make movements of the head and neck as if choking; there is fever, diarrhea, drooping wings, great depression, a tendency to sleep, and finally suffocation and death.

When the disease is limited to the large air sacs the only symptoms are weakness and progressive loss of flesh. If the small air sacs of the bones are involved there may be lameness, with swollen and inflamed joints. The symptoms in brooder chicks are similar to those of white diarrhea (page 9). The disease is always fatal. Young chicks die within a few days. Older birds may live one to four or more weeks after the appearance of symptoms.

Post-mortem appearance.—The walls of the windpipe, air passages in the lungs, and air sacs in the abdominal cavity show whitish or yellowish nodules in the early stages of the disease. Later the walls are covered by elevated dirty-yellow or greenish layers, which represent growths of the mold.

Prevention.—The disease is prevented by giving only clean and bright straw or chaff for the fowls and brooder chicks to scratch in, by keeping the houses and yards clean, and using for feed grain and meal which are sound and entirely free from mold. The sick birds should be removed from the flock and the bodies of those which die should be burned or buried.

CHOLERA.

Cholera is a highly infectious, rapidly fatal disease of all domesticated birds. Birds of any age are susceptible.

Cause.—It is caused by *Pasteurella choleræ gallinarum*, a germ which multiplies to enormous numbers in the blood and various organs of the body, producing a septicemia or blood poisoning. The disease is carried by sick or recently recovered birds which have been placed in a healthy flock, by wild birds, or by persons, animals, or poultry utensils which have been on infected premises. It spreads rapidly throughout the flock, owing to the fact that the first birds to become infected give off great numbers of the germs in their droppings and these germs are picked up by the other birds in feeding and drinking.

Symptoms.—The first symptom is a yellowish coloration of the droppings. This is followed by a yellowish, brownish, or greenish diarrhea. The bird becomes droopy, feverish, and sleepy, and sits with the head drawn down to the body or turned backward and resting in the feathers about the wing. Appetite diminishes and thirst increases. Breathing becomes difficult and may be heard at some distance. Finally the weakness is such that the bird can not stand, but lies with the beak resting on the ground. It sleeps so soundly for some time before death that it can hardly be aroused. The comb and wattles may be a dark bluish red and the skin of the breast and abdomen is frequently reddened.

In very acute cases no symptoms are seen; the birds may be found dead under the roosts or they may fall while feeding or moving about and die in a short time. During an acute outbreak sickness is seldom noticed more than 24 hours before death, which usually occurs within three days from the time of infection.

Cholera may destroy the greater part of a flock in a week and then disappear, or it may linger in a chronic form for months, only occasionally killing a bird. The chronic form is characterized by a continually increasing weakness, loss of weight, paleness of head, and finally an exhausting diarrhea. Sometimes one or more joints of the wings or legs swell, the bird becomes lame, and later the swellings break and discharge a creamy or cheesy mass.

Post-mortem appearance.—The heart has red spots or hemorrhages on its surface. The first portion of the intestines is congested and hemorrhagic, and the contents consist of a pasty mass, which may be bloodstained. The blood vessels of the visceral organs are congested. The liver may be enlarged and darker in color and the spleen may be swollen. A sticky fluid is frequently present in the mouth and nostrils.

Treatment.—Since treatment of affected birds is futile, the aim should be to prevent so far as possible the spread of infection. The first fowls showing acute feverish symptoms should be destroyed by a method which would guard against the contamination of the premises by infected blood. The carcasses should be burned or buried deep. The healthy fowls should be moved to new quarters if possible and carefully watched for signs of disease. Houses and runs should be thoroughly cleaned at frequent intervals and disinfected with carbolic acid in 5 per cent solution, compound cresol in 2 per cent solution, or a reliable coal-tar disinfectant in proper dilution. The drinking water may be made antiseptic by adding one-third teaspoon of permanganate of potash to each gallon, a procedure which serves to prevent the spread of disease through the water and also is a convenient means of administering an internal antiseptic.

CHOLERALIKE DISEASES.

There are several diseases similar to cholera which have been investigated and described as different because the bacteria which cause them differ in some of their characteristics. The symptoms and the changes which are seen after death are so nearly identical that it is only by studying the bacteria that any one of these diseases can be distinguished from the others. For the practical purpose of combating them in the poultry yard we may therefore group these diseases together.

Cause.—Certain germs (bacteria), like *Bacterium coli*, which are nearly always found in the intestines of healthy birds, have more or less power to produce disease, but the sound, healthy bird is able to resist them under favorable conditions. When the resisting powers of fowls are diminished by exposure to cold, hunger, thirst, and exhaustion, as occurs during long shipments by rail, these germs may cause diseases. In some countries the sickness which develops from these conditions is called " the transportation disease."

It happens sometimes that these diseases develop in insanitary poultry yards, possibly because of the large numbers of germs taken into the bodies of the birds. When the germs begin growing in the tissues of fowls they soon increase their virulence, and the disease which they cause may rapidly spread from fowl to fowl until most of the birds are dead.

The choleralike diseases, therefore, may either develop in the poultry yard from insanitary conditions, or be introduced by contagion carried by new birds which are added to the flock, by birds which have been in exhibitions, by wild birds which fly from one poultry yard to another, or by various animals, such as dogs, cats, and rats. Birds which recover from a disease may sometimes carry the germs and disseminate the contagion for six months or a year after they are apparently well.

Symptoms.—The manifestations of these diseases are much like those of cholera and for practical purposes need not be described separately. The choleralike diseases are differentiated from true cholera by their slower spread and lessened mortality.

Treatment.—Treatment and prevention follow the same lines advised for cholera.

FOWL TYPHOID.

Fowl typhoid is an infectious disease of mature chickens which has not been observed in other domestic birds. It attacks the blood and internal organs.

Cause.—The disease is caused by *Bacterium gallinarum*, a microorganism which is introduced on the premises through the agency of carriers, such as infected fowls, material from infected poultry yards, by free-flying birds, or on the feet of persons or animals which have been on infected premises. Typhoid spreads through a flock in a manner similar to cholera and most of the infectious diseases, but is not so destructive as acute cholera.

Symptoms.—These are drowsiness, fever, loss of appetite, and general weakness. The droppings are soft and yellowish or greenish. The membranes of the head, comb, and wattles are usually paler than normal, but in acute cases may be darkened with venous congestion. Complete prostration may develop in from several hours to one or two days before death. Symptoms become noticeable in from 4 to 6 days after infection takes place and last in fatal cases from 4 to 12 days.

Post-mortem appearance.—The internal parts of the body other than the liver and the spleen have a pale appearance. The mucous membrane or interior wall of the intestine is usually pale. The blood is thin, pale red in color, and does not clot readily. The liver is greatly enlarged and generally dotted with grayish spots. It has a tendency to break easily. The spleen is often swollen, pulpy, and filled with grayish spots. The kidneys are somewhat enlarged and lighter in color or slightly injected with blood. The heart appears normal or else pale, with grayish spots on its surface.

Treatment.—The treatment advised for cholera applies also to fowl typhoid, since sanitary measures must be depended on for its control.

TUBERCULOSIS.

Tuberculosis is a chronic infectious disease of domestic and wild birds. It is most common, however, in the fowl and pigeon. It is readily contracted by pigs, rats, and mice, but man is rarely affected by avian tuberculosis. Parrots and canaries are quite susceptible to human tuberculosis, while fowls are practically insusceptible.

Cause.—The disease is caused by *Mycobacterium tuberculosis avium*. Tuberculosis is generally brought into the poultry yard with fowls that are purchased from infected flocks or with the eggs of diseased birds that are obtained for hatching. If the disease exists in neighboring flocks the contagion may be carried by small birds or animals passing from one yard to another. A peculiarity of tuberculosis of birds is that the liver and intestines are nearly always very severely affected, and that as a consequence the organisms are very numerous in the intestinal contents and are scattered with the droppings everywhere that the fowls go. The introduction of a single diseased bird, therefore, may cause the infection of the greater part of the flock in a few weeks. In the same way, when wild birds contract the disease, the germs are carried and deposited in all the yards which they visit.

The eggs of diseased birds frequently contain the microbes, and the young chicks hatched from such infected eggs are diseased when they leave the shell and soon infect the poultry with which they run. Moreover, since the infertile incubated eggs are often fed to chickens, it is clear that even the eggs which do not hatch may introduce the contagion unless they are cooked before feeding.

Pigs, rats, and mice are especially liable to be infected with fowl tuberculosis from eating the carcasses of birds which have died, and these animals serve to keep up the contagion and may communicate it to other fowls, especially if the latter eat the carcasses of rats or mice that died of the disease.

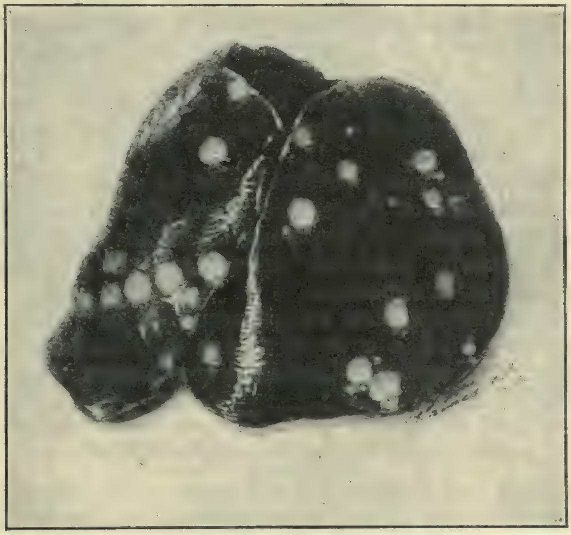

FIG. 6.—Liver of pheasant, showing lesions of tuberculosis.

Symptoms.—Although birds may become infected at any age, the disease usually progresses slowly and symptoms are generally not observed until the affection has reached an advanced stage. Hence it is the older fowls, those more than 1 year of age, which display the most pronounced symptoms and show a high death rate.

Signs of disease begin with gradual loss of weight, wasting of the muscles, especially noticeable in the breast, paleness of the comb, and, toward the end, dullness, sleepiness, and diarrhea with yellowish or greenish droppings. Very often there is at the same time a tuberculous inflammation of the joints and of the sheaths of tendons, which is revealed by lameness and swelling of the joints and legs. Occasionally the skin over the swollen joint breaks, the interior of the joint is ulcerated, and a small quantity of cheesy material is discharged. Deaths in the flock occur at intervals. Affected birds may live only a short time after symptoms are noticed, or they may live for weeks.

Post-mortem appearance.—On post-mortem examination grayish-white or yellowish colored tumors of varying sizes are observed in the internal organs, but especially in the liver, spleen, and intestines. These tubercles when cut open present a solid, grayish, glistening interior which in the larger ones exhibits yellowish centers, or a number of yellowish points. Those of more advanced growth show extensive yellowish, cheesy, or crumbly masses in their interior (Fig. 6).

Treatment.—There is no treatment that will cure tuberculous birds. The most thorough method of eradication is to slaughter the entire flock when indications point to an extensive outbreak. Fowls in good flesh, showing no lesions or slight ones, may be used for food. Those badly diseased and all visceral organs of the others should be destroyed.

The chicken houses, inclosed runs, and all eating, drinking, and other utensils should be thoroughly cleaned and disinfected with a strong disinfectant solution. After disinfection the premises should be kept free of fowls for a year if possible, or new stock may be placed on ground which has not been occupied by poultry for a year or more. In restocking, obtain birds or eggs for hatching from flocks which have shown no signs of an infectious disease for a year or more.

When the breeding value of the fowls or other interests make it undesirable to dispose of the entire flock, tuberculosis may be controlled to a great extent by disposing of all birds at the end of the second laying period. Younger birds should be disposed of whenever they appear to be abnormal.

More detailed information on tuberculosis of fowls is given in Farmers' Bulletin 1200, a copy of which may be had on request to the Division of Publications, United States Department of Agriculture, Washington, D. C.

ENTEROHEPATITIS (BLACKHEAD).

Enterohepatitis or blackhead is a disease of the intestine and liver which is most frequent in and most injurious to turkeys, but which may also attack chickens. In the course of the disease the head often becomes dark colored or nearly black, and for that reason it is popularly known as blackhead, although it is only the internal organs that are directly affected by the disease. The disease is widely disseminated and in some localities has made the production of turkeys nearly impossible.

Cause.—The disease is caused by a parasitic protozoan micro-organism, which leaves the body of the sick bird, or carrier, with the excrement and infects other birds by entering the digestive organs with the feed and drink. Fowls, while not readily infected, serve as carriers of the organism and spread the disease to poults.

Some investigators found that when infective blackhead material was fed to turkeys at the same time that eggs of the cecum worm, *Heterakis papillosa* (discussed on page 31), were fed to these birds the turkeys developed blackhead, whereas when the infective blackhead material was fed without these worm eggs the turkeys did not readily develop blackhead. Other experiments have pointed to the Heterakis eggs as carriers of the blackhead organism. It appears from this that these worms may be of great importance in establishing infection with blackhead when the organism of the disease is present. For this reason, as well as for other reasons, it is advisable to use appropriate measures for the control of these worms.

Symptoms.—The symptoms of enterohepatitis are most frequently seen in young turkeys, commonly called "poults," which are from 2 weeks to 3 or 4 months old. In the more acute cases the poults usually die within a few days after symptoms appear. In less acute cases and in older turkeys the course of the disease is longer.

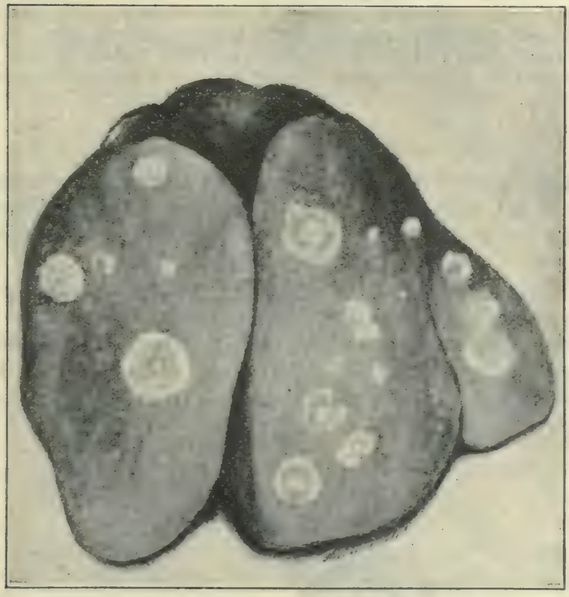

FIG. 7.—Enterohepatitis (blackhead). Liver of turkey, showing necrotic areas.

The affected birds at first appear less lively than usual, are not so active in searching for feed, and when fed show a diminished appetite. Diarrhea is a nearly constant symptom, naturally associated with the inflammation of the ceca or two blind pouches of the intestine. As the disease progresses there is dullness and weakness, the wings and tail droop, and there is often the peculiar discoloration of the head. There is increasing prostration and loss of weight; the affected birds, instead of following their companions, stand about in a listless manner, indisposed to move and paying little attention to what occurs about them.

Post-mortem appearance.—In nearly all cases of blackhead the liver is enlarged and covered with degenerated, yellowish or yellowish-green circular spots of varying size (Fig. 7). The ceca, or two intestinal pouches, are distended, their cavities being filled with a grayish friable or cheesy mass. This represents destroyed tissue resulting from the action of the blackhead organism on the intestinal wall.

Prevention.—Since treatment of diseased birds has not proved to be successful, the only hope of success at present against blackhead is in prevention. The measures of prevention which give the greatest promise are as follows:

(1) Obtaining eggs from birds believed to be healthy; (2) wiping the eggs with a cloth wet with denatured alcohol (80 to 90 per cent) before they are placed in the incubator or under the hen for hatching, to remove any contagion that might be on the shell; (3) hatching in an incubator, or at least removing the eggs from under the hen a day or two before hatching would occur, wiping with alcohol, and finishing in an incubator, in order to avoid exposing the poults to the hen; (4) placing the young poults in a brooder on inclosed ground at a distance from all other domesticated fowls and not recently occupied by other fowls; (5) excluding, so far as possible, pigeons, other wild birds, and rats and mice from the houses and runs occupied by the turkeys; (6) frequent disinfection of the houses, feeding troughs, drinking fountains, etc.; (7) immediate killing of diseased birds and the destruction of their bodies by fire. The turkeys should be confined in the inclosure until grown and given sour milk or buttermilk frequently.

GOUT.

Gout is marked by the presence of an abnormal quantity of uric acid in the blood, which results in the deposit of urates on the internal organs (visceral gout) or more frequently in the joints (articular gout).

Cause.—The increased quantity of uric acid may be induced by several causes. Prolonged feeding on substances rich in albumin, especially if associated with lack of exercise, is probably the most frequent predisposing factor. Diseases which affect the urinary organs, causing a failure to eliminate the uric acid properly, play an important part in the causation of gout.

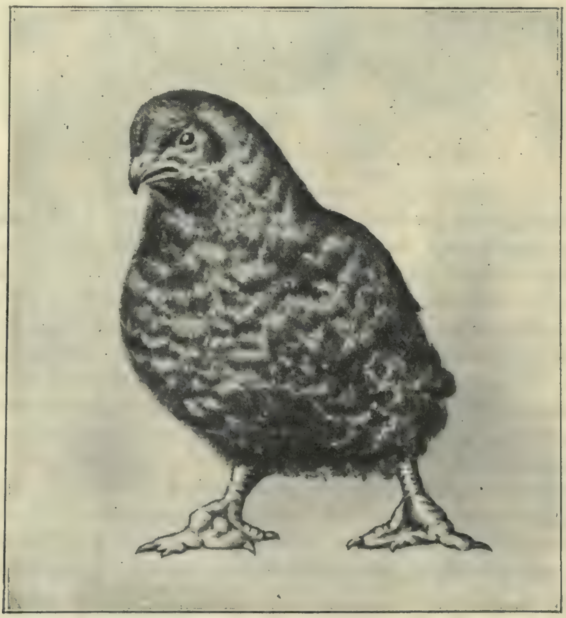

FIG. 8.—Chicken affected with articular gout. (After Kionka.)

Symptoms.—The joints of the feet are most frequently and severely affected, although the wing joints may also be involved. At first the joints are swollen and painful. Later the lesions form into nodular, tumorlike growths which vary in size and may be either hard or fluctuating. (Fig. 8.) Frequently the swellings burst, discharging a yellowish, turbid material containing urates. The bird avoids walking as much as possible and remains in a sitting position. The general health becomes affected and emaciation gradually occurs, with weakness and frequently diarrhea. Visceral gout is apparent on autopsy only. The internal organs and serous membranes are found covered with chalklike deposits. The course of the disease is slow.

Treatment.—Artificial Karlsbad salt has been beneficial. This is prepared by mixing together sodium sulphate 22 grams, potassium sulphate 1 gram, sodium chlorid 9 grams, and sodium bicarbonate 18 grams. Six grams (or one-fifth of an ounce) of this mixture are added to 1 quart of drinking water. Tincture of colchicum in from 2 to 5 drop doses per bird may also be used. Enlarged joints may be opened and the contents washed out. When moderately severe symptoms are shown, it will be best to fatten and kill the bird before the onset of emaciation. When several fowls in the flock develop symptoms, the diet should be looked into and corrected if necessary. Often a reduction in the quantity of meat scrap and an increase in green feed will prevent additional cases. The entire flock should receive a dose of Epsom salt, one-third teaspoon to each adult bird.

TUMORS.

Tumors are of frequent occurrence in birds and present a number of varieties. The largest percentage is found in fowls more than 2 years old. In hens the egg organs are affected in more than 50 per cent of cases. Bird tumors have a marked tendency to break down and cause death from internal hemorrhage. Tumors on the skin are easily recognized, while internal ones may be suspected when an individual in the flock shows poor condition, increasing droopiness, or emaciation.

Treatment.—There is no treatment for internal tumors. External ones can be removed satisfactorily in some cases by an operation. Since many of the growths, however, are of a malignant or cancerous nature, it is best to dispose of the bird.

ROSE-CHAFER POISONING.

Rose chafers are extremely poisonous to chickens under 10 weeks old. When these beetles are on vegetation chickens devour them readily, and only a few are necessary to cause death.

Symptoms.—Signs of poisoning may appear as early as one hour after feeding on the chafers, and death may follow in one hour after the appearance of symptoms. If sufficient poison is not absorbed to cause death the bird recovers. The affected chicken becomes drowsy, shows weakness of the legs, and falls over on its side. There may be convulsions. Sharp cries are frequently emitted, and the head and neck are retracted over the back of the bird. The only internal sign is the presence of rose chafers in the crop.

Treatment.—The rapid action of the poison renders treatment futile in birds showing symptoms. When the nature of the trouble is realized, others of the flock which had opportunity to eat chafers should be given Epsom salt in the proportion of one-fourth teaspoon, mixed with a small amount of feed, to each bird. Preventive measures consist in keeping young chickens in inclosed runs or at points where they will not have access to grapevines, rosebushes, and shrubbery when the insects are prevalent. This corresponds somewhat closely to the time of first blossoming of the various garden flowers.

LEG WEAKNESS.

Leg weakness is a term commonly used to describe a condition of birds in which there is unsteadiness of gait or inability to stand. It is not a specific disease, but is a symptom associated with a number of diseases.

Cause.—Among the causes may be mentioned the various infectious diseases which produce extreme debility, such as cholera and the choleralike diseases, fowl typhoid, coccidiosis, enterohepatitis or blackhead of turkeys, and white diarrhea of chicks. Other causes are mineral and food poisons, including those of vegetable and animal origin, rickets from lack of lime salts in the feed, polyneuritis from lack of vitamins in the feed, close confinement of growing chicks, and paralysis.

Treatment.—An effort should be made to determine whether an infectious disease or poison is the cause and to treat accordingly. If deficiency in necessary mineral or other elements in the feed is the probable cause, a wide variety of feed with plenty of green feed should be given and the birds allowed ample room for exercise or turned out on free range. Ground oyster shells or calcium phosphate should be fed freely, and 1 dram of copperas may be added to each gallon of drinking water. Leg weakness in young chicks, when due to confinement with lack of sunlight, soil, and space for exercise, is corrected by giving cod-liver oil, 2 or 3 drops per bird, mixed in the feed daily.

LAMENESS IN GEESE AND DUCKS.

Geese and ducks are affected with an inflammatory condition of the joints of the feet and wings, associated with an internal infectious disease.

Cause.—The disease is caused by a microorganism known as *Staphylococcus pyogenes aureus*, which multiplies in the internal organs and the bones and joints.

Symptoms.—Principally young ducks and geese are affected. The disease may be acute, causing death in from two to four days, or chronic, with symptoms continuing for more than two weeks, when death may occur or gradual recovery take place. In acute cases there is general depression, diarrhea, and discharge from the eyes. In chronic cases the general symptoms are less marked but emaciation is pronounced. The characteristic symptoms in both cases are lameness and swelling of the joints of the legs or feet. Usually only one leg may show lameness, and the hock joint or one of the toe joints is most often affected. The swellings are hot and painful. The bird frequently lies on its breast with legs extended backward and if forced can move only short distances by flapping the wings. Sometimes the wing joints are swollen and the wings droop.

Post-mortem appearance.—The intestine is inflamed and its contents are slimy and reddish in color. The liver and spleen are enlarged. The diseased joints are reddened, swollen with fluid, and contain yellowish, fibrous, or cheesy exudates.

Treatment.—Acute cases do not respond favorably to treatment. The joints should be painted daily with tincture of iodin. Separate the sick from the well and keep the houses and utensils clean and disinfected. Keep the ducks and geese from stagnant water and when giving drinking water dissolve one-third teaspoon of permanganate of potash in each gallon.

WING LAMENESS IN PIGEONS.

Pigeons have swollen and disabled wing joints as a result of tuberculosis, gout, or mechanical injuries. They also are affected with a disease seen on the head, neck, or wings which is caused by an infectious organism resembling somewhat the causative agent of tuberculosis. This germ grows underneath the skin and induces the formation of lumps of yellowish cheesy material which enlarge to the size of a marble. When these lumps are present in the wing, especially near a joint, flight may be impaired or rendered impossible.

Treatment.—Lance the skin over the growth, press out the ball of cheesy matter and paint the cavity with tincture of iodin daily for several days.

BUMBLEFOOT.

Bumblefoot is a term applied to a swelling of the foot and is most often seen in fowls. It may result from bruises, as in the case of heavy birds jumping from high perches to hard surfaces, or it may be due to cuts or punctures of the skin of the foot which becomes infected by germs. These organisms set up an inflammation and the formation of fluid or cheesy suppurative material usually in the ball of the foot.

Treatment.—In some cases the application of tincture of iodin to the swollen area daily for several days will bring about recovery. If the swelling is hot and has the appearance of an abscess it should be lanced and the contents washed out. The interior of the abscess is then soaked with 5 per cent carbolic acid or tincture of iodin and the foot bandaged. The fowl should be placed in a small compartment without a perch and the wound disinfected daily for several days.

EGG-BOUND.

The condition known as "egg-bound" (failure to pass the egg in the normal manner) is of frequent occurrence in fowls, especially in pullets when beginning to lay.

Cause.—The difficulty may be due to inflammation, stricture, or tumor formation in the posterior part of the egg passage. Some times malformed or double-yolked eggs are responsible. In pullets the usual cause is an attempt to lay large-sized eggs before the egg passage has become sufficiently dilated to accommodate them.

Symptoms.—Affected hens become restless and make frequent visits to the nest in efforts to lay. The straining may cause inflammation and often eversion of the oviduct (egg tube) through the vent. Others of the flock, attracted by the inflamed, protruding parts, peck at them and tear out portions of the egg passage and intestine, causing the death of the hen. If prolapse does not occur the distressed fowl may continue her effort to lay until successful or until overcome by weakness or internal hemorrhage from rupture of the oviduct. The egg may be felt by passing the forefinger through the vent.

Treatment.—The surest method of treatment is to remove the egg by the following procedure: Pass the forefinger through the vent. With the other hand pressing on the abdomen of the fowl force the egg toward the vent, guiding it by the aid of the inserted finger. When the shell is observed through the vent puncture it with an awl or other sharp-pointed instrument, break it in pieces, and withdraw these and the egg contents. Isolate the bird and inject cold water into the cloaca (the common passage into which the intestine and the oviduct open) to reduce the inflammation. If the oviduct has been everted through the vent, clean and push the parts back and inject cold water frequently until the tissues remain in place.

VENT GLEET.

Vent gleet is an infectious venereal disease of fowls which is spread by the rooster in treading. Its causative agent is not known.

Symptoms.—There is inflammation of the cloaca and vent. The skin around the vent is swollen, reddened, and ulcerated, and an offensive odor is usually present. The droppings are foul smelling and liquid and are frequently voided. Other chickens may peck at the inflamed part and often tear the cloaca and rectum, causing death of the victim.

Treatment.—The disease is very resistant to treatment. It is usually better to destroy the bird. If treatment is desired, 5 per cent carbolic acid or 2 per cent carbolic ointment may be applied daily over the affected area. Argyrol in 20 per cent solution may be injected into the cloaca twice daily. Remove the roosters from the flock while the disease is present, and destroy any found affected.

FEATHER PULLING.

Feather pulling is a vice which may originate from several causes, such as close confinement with idleness, lack of sufficient mineral or animal matter in the feed, or the presence of itch mites at the base of the feathers (see "Depluming scabies," page 36). A particularly vicious hen may begin the practice, which may be imitated by others of the flock and continued as a habit.

Treatment.—Allow as much room as possible for exercise. Scratching for feed in deep litter helps to keep the birds busy. Provide a variety of feeds with meat scrap and plenty of green feed and ground oyster shell. The early discovery and isolation of the principal offenders will frequently check the trouble where it is merely a habit and not due to other causes. If mites are present, treat as for depluming scabies.

TOE PECKING.

Toe pecking is observed in young chicks, especially those confined in brooders. Chicks peck at feed stuck to the foot and wound the skin. The taste of blood causes them to continue pecking at the toes of the victim and to attack other chicks. They may also peck at the vent and disembowel the chick in a short length of time.

Treatment.—Remove all wounded birds as soon as they are observed and isolate them until recovery is complete. Keep the chicks occupied by hanging vegetables or bone with shreds of meat attached at a height which will cause the chicks to jump in reaching them.

IMPACTED CROP (CROP-BOUND).

The affection known as "crop-bound" or impacted crop is an overdistended and paralyzed condition of the crop, generally caused by overeating or by swallowing coarse and indigestible substances, such as feathers or fibrous feeds. In cholera the crop is paralyzed as a result of the disease.

Symptoms.—The first symptom is a loss of appetite, or an effort of the bird to swallow without being able to do so. The crop is seen to be very large and much distended with contents which are more or less firmly packed together. If permitted to continue, the condition becomes aggravated, the breathing difficult, and death may result.

Treatment.—The contents of the crop may be removed sometimes by forcing the bird to swallow a teaspoon or more of sweet oil, and massaging the lower part of the gullet, if it contains feed, or, if not, part of the crop nearest to the gullet, until the contents are softened and may be pressed toward the head. This is made easier by holding the bird head downward. By continued manipulation the greater part of the material may be removed. The bird should not be permitted to eat for several hours after it is relieved. If this plan of treatment is not successful, the crop must be opened with a sharp knife and the contents removed through the opening, using for this purpose a coffee spoon, a buttonhook, small forceps, a bent wire, or other suitable instrument. Then wash out the crop with clean, warm water. The opening should not be more than an inch in length and should be closed with three or four stitches, first in the wall of the crop and, when this is finished, an equal number in the skin. Each stitch should be made and tied separately. Coarse white silk is the best material, but if it is not at hand ordinary cotton thread may be used. Feed on milk and raw egg beaten together for a day or two, and gradually change to soft mash.

INFLAMMATION OF THE STOMACH OR INTESTINES.

Inflammation of the stomach or intestines, when not the result of one of the contagious diseases to which reference has been made, is generally due to digestive troubles or to eating moldy or spoiled feed or irritating mineral poisons. It is indicated by loss of appetite, dullness, and constipation or diarrhea. It may be treated by giving one-half teaspoon of Epsom salt or 2 teaspoons of castor oil, and feeding a soft mash for a day or two.

LIMBERNECK.

The condition known as limberneck is a symptom of several diseases, among which are botulism and ptomain poisoning, which are characterized by a paralysis of the muscles of the neck, which makes it impossible for the bird to raise its head from the ground. This condition is due to the absorption from the crop or intestines of poisons which act upon the nervous system and cause paralysis. It is generally associated with the eating of spoiled feed or putrid meat in which certain poison-producing organisms are growing or of fly maggots which have bred on such material.

Treatment.—The best treatment is to give a full dose of purgative medicine, that is, one-half teaspoon of Epsom salt, or 3 or 4 teaspoons of castor oil for a grown fowl. Unless treatment can be given very soon there is little hope of saving the bird. Spoiled canned goods should not be fed to chickens. Carcasses of fowls or other animals should be burned or buried deep as soon as found.

DIARRHEA.

Diarrhea is present in nearly all the infectious diseases. It may occur, however, independently of the action of infectious organisms.

Cause.—Simple diarrhea may result from digestive disturbances, fermentation in the food passages, moldy feed or putrid flesh, irritants or poisons, too much meat scrap, sudden changes in the feed, or an unusually large quantity of green feed.

Treatment.—Give the entire flock Epsom salt in the proportion of one-half teaspoon to each grown bird. The salt may be mixed in a mash. Correct the feeding.

FAVUS (WHITE COMB).

White comb, baldness, or favus of fowls is a contagious disease that begins with the formation of grayish-white spots on the comb, ear lobes, or wattles (Fig. 9).

Cause.—This disease is caused by a fungus called *Lophophyton gallinæ* and is transmitted from fowl to fowl by simple contact. It is most frequently seen affecting chickens and turkeys, but attempts to infect pigeons have failed. It is also easily inoculated on man, producing large, red, scaly patches on the skin, and the patches sometimes develop spontaneously, being no doubt due to contagion from affected fowls.

Symptoms.—Favus generally begins on the bare parts of the head as small, white, or grayish spots, round or irregular in form, which increase in number and size and join together until the whole surface is covered. The affected spots are covered with dry, scaly, dirty-white crusts with an irregular surface. As the disease advances the neck and body are gradually invaded and the feathers become brittle and break off, leaving a deep depression in the center of a cup-shaped disk. Occasionally the disease is inoculated into the feathered parts of the skin and begins there instead of on the bare parts of the head, but this is exceptional. The disease when limited to the comb and wattles may disappear without treatment, but after it has invaded the feathered parts it almost invariably continues to advance, and the birds grow weaker until they die from this disease or some other to which their debilitated condition has made them abnormally susceptible.

Treatment.—When only the bare parts of the head are affected the disease may be cured by applying tincture of iodin to the diseased spots. An ointment of calomel 1 part, vaseline 8 parts, or a mixture of soft soap 20 parts, carbolic acid 1 part, may be applied daily. An ointment of red oxid of mercury 1 part, vaseline 8 parts, is also used, as well as olive oil containing 2 per cent carbolic acid. It is essential to separate the affected bird from the flock. If the feathered parts of the body are affected it is better to kill the bird, as the treatment would be long and expensive and there would be danger of spreading the disease. The disease should be prevented by excluding all affected birds, by burning the bodies of those that die or are killed, and by disinfecting the houses where diseased birds have been.

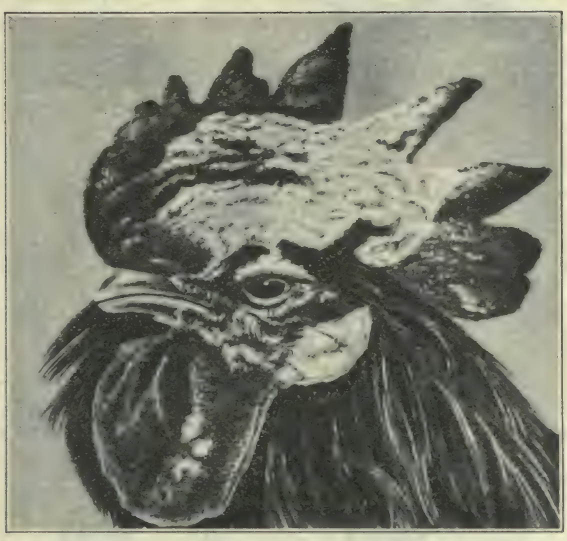

FIG. 9.—Favus ("white comb"). (After Sabouraud.)

GAPES.

Gapes is a disease of chickens which develops during the first few weeks of their lives, and is made evident by frequent gaping.

Cause.—It is caused by a parasitic worm (*Syngamus trachealis*) which attaches itself to the internal surface of the windpipe, sucks blood from the mucous membrane, and obstructs the passage to such an extent as to interfere seriously with the breathing. The insufficient supply of air, the loss of blood, and the diminished activity in looking for feed lead to a weak and bloodless condition and often to death from overcrowding or exposure that a well chick would be able to resist without injury. Sometimes so many worms accumulate in the windpipe that breathing becomes impossible and the chick dies from suffocation (Fig. 10).

The worm which causes this disease is sometimes called the red worm or the forked worm because of its color and of the fact that the male and the female are so firmly grown together that they can not be separated without tearing the tissues. The two worms united in this manner appear at first sight like a single worm with two necks and two heads. The female is a little more than one-half inch in length and the male one-fifth inch. The heads of both are attached to the mucous membrane, irritating it so much that there is an increased secretion of mucus. which collects and increases the difficulty of breathing.

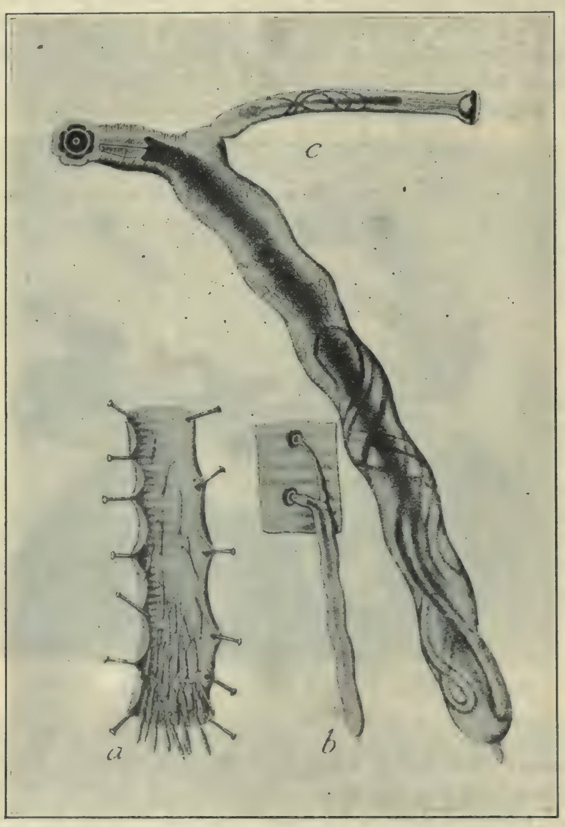

Fig. 10.—The gapeworm of fowls. (*a*) Windpipe of chick slit open, showing worms attached; (*b*) worms slightly magnified; (*c*) worms greatly magnified. (After Mégnin.)

A large number of eggs develop in the female worm while in the windpipe, and these eggs, microscopic in size, are either thrown out by the chick while sneezing, or are swallowed, pass through the stomach and intestines unharmed, and are scattered with the droppings. After a short period of incubation the eggs contain young worms capable of continuing their development if swallowed by young chickens. These young worms, after hatching out or while still contained in the egg, are swallowed with feed or drinking water. They may live a long time in the soil and sometimes are taken into the digestive tubes of earthworms. In badly infested ground a considerable proportion of the earthworms, if eaten, may be capable of causing the disease in chicks.

These facts explain why ground upon which chickens are raised year after year becomes so badly infested and how the infection is carried over from one year to the next. The worms are carried by turkeys and various kinds of wild birds, which thus help in spreading the infection. When the young worms, or eggs containing sufficiently developed young worms, are taken into the stomach of the chick, the parasites find their way in a few days to the windpipe, where they may be seen already attached and grown to a considerable size within a week.

Symptoms.—The symptoms of gapes are observed most frequently in chicks from 10 days to 4 weeks old. The affected birds cough or sneeze with an abrupt, whistling sound and a more or less labored effect. Very soon they begin to gape, extending the neck and opening the beak, thus indicating that they are not getting a sufficient supply of air. During the first few days the appetite is ravenous, but in spite of the quantity of feed eaten the birds become weak, anemic, and emaciated. Later there is little appetite, the birds are dull, have difficulty in keeping with their companions, and as the disease advances their wings droop and they stand with closed eyes and head drawn back into the body. Frequently the head is thrown forward and the bird gapes or gives the head a convulsive shake in order to loosen the obstruction in the windpipe and permit the entrance of air. In this condition it is liable to die suddenly from suffocation, from exhaustion, or it may be trampled to death by its fellows at night.

The more vigorous and the older birds show only mild symptoms or none at all. They may gape occasionally, but their appetites remain good and they continue to grow. As the soil becomes more and more intensely infested, however, the proportion of the chicks which are able to resist the attacks of the these parasites becomes less, until finally it may be almost impossible to raise chickens on the premises.

Treatment.—Reliance must be placed on prevention rather than cure, because a chick 2 or 3 weeks old has not sufficient value to warrant the expenditure of much time or medicine in its treatment.

Sometimes it is advisable to extract the worms or to inject into the windpipe some liquid that will kill them. Extractors are made in various ways. Generally a small quill feather is stripped of all its web except a small tuft at the end, and is used either dry or moistened with kerosene or oil of turpentine. A fairly good extractor may be made by taking a hair from a horse's tail, bending it in the middle, and twisting the two ends together so as to form a loop; or a similar loop may be made by cutting the hair, laying the two pieces side by side, tying a knot near the end, trimming the short ends close to the knot, and twisting the long ends together. These homemade extractors have been imitated in the poultry-supply trade by doubling and twisting a small, flexible wire which carries a few moderately stiff hairs to scrape off the worms.

All these extractors are used in the same manner. The chick's beak is forced open with the thumb and fingers of the left hand, while the extractor is held in the right hand. When the glottis, which is the small aperture at the root of the tongue, is opened for breathing, the extractor is carefully inserted and pressed downward into the windpipe. The neck should be kept extended in a straight line, so that the extractor will enter freely and not injure the delicate walls of the windpipe. At the first insertion the loop or brush should not pass more than an inch below the glottis; then it should be given two or three turns between the thumb and finger and withdrawn. If any worms adhere to it they should be dropped into a basin of hot water or kept and burned. The extractor may now be inserted a little deeper, and so on until it reaches nearly the full length of the neck. If the slightest resistance is felt to the entrance of the extractor, it should not be pressed upon or inserted any farther. In all cases the extractor must be quickly withdrawn to avoid suffocating or otherwise injuring the chick. Often 8 or 10 worms may be removed in this manner, and if the treatment has not been so rough as to cause injury the bird will be very much improved.

The best method of prevention is to put the chicks, when hatched, on fresh ground; to remove, place in a separate coop, and treat any that show symptoms, and to plow and seed down the old infected runs, not permitting chickens to go on them for two or three years.

Because turkeys very commonly harbor gapeworms, they are important sources of infection for young chicks, usually unsuspected sources, as they rarely show evidence of the presence of the parasite. When turkeys and chicks are reared together it is difficult to avoid losses from gapes among young chicks.

INTESTINAL WORMS.[2]

Most chickens are infested with one or more species of parasitic worms. These worms may be present in small numbers and may do no apparent damage. If, however, chickens are kept under conditions favoring the spread and multiplication of the parasites (for example, overcrowding in small pens), the fowls may become heavily infested, and in consequence they may be weak, unthrifty, emaciated, and unproductive. Often they show evidence of digestive disturbances in the form of constipation or diarrhea. The nature of the disease may often be determined by examining the birds that die, or by killing one that is very thin and weak. The intestines should be opened with scissors and their contents mixed with water in a dark-colored pan. The white or yellowish worms, which may be more or less cylindrical or threadlike, or flattened and segmented, can then be detected easily, and appropriate treatment applied to the rest of the flock.

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[2] The section on intestinal worms (roundworms and tapeworms) was prepared by Maurice C. Hall, of the Zoological Division.

ROUNDWORMS.

Of the various species of roundworms occurring in the digestive tract, two deserve special mention. One of these species is the large roundworm (*Ascaridia perspicillum*, Fig. 11), a white or yellowish worm which occurs in the small intestine and attains a length of from 1 to 4½ inches when fully grown. These worms may be present in such numbers as to block the intestine. The other worm is the cecum worm or heterakid (*Heterakis papillosa*, Fig. 12), a white worm which occurs in the ceca, the two blind guts extending back along the small intestine from its union with the large intestine. This worm attains a length of from three-tenths to one-half inch. These worms are sometimes present in enormous numbers and may cause a serious inflammation of the ceca. They are also of importance, as already noted (page 18), as apparently involved in the causation of blackhead in the presence of infective blackhead material.

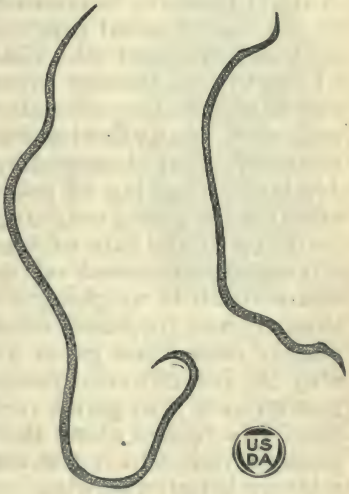

FIG. 11.—The large roundworm, *Ascaridia perspicillum*, from the intestine. (After Wickware, 1917.) (Natural size.)

Treatment.—The treatment given below has been recommended by the agricultural eexperiment station of California for the removal of the large roundworm. In experiments carried on in the Bureau of Animal Industry this treatment removed about one-fifth of the cecum worms, and it is not so satisfactory for removing these worms as is the method noted later for their removal. It has, however, the advantage of being a mass treatment and not requiring the handling and treatment of each individual bird, and if repeated at intervals of 3 or 4 weeks it may be of some value in diminishing infestation with cecum worms. The treatment is as follows:

For 100 birds, steep 1 pound of finely chopped tobacco stems for 2 hours in water enough to cover them. Mix the stems and the liquid with one-half the usual ration of ground feed. The day previous to treatment withhold all feed, giving water only. After the birds have been thus fasted for 24 hours, feed the mash thus prepared, and 2 hours after it is cleaned up give them one-fourth of the usual quantity of ground feed mixed with water in which Epsom salt has been dissolved at the rate of 11 ounces for each 100 birds. The treatment should be repeated 10 days later to remove the large roundworms, and, as noted, should be repeated at intervals of from 3 to 4 weeks as a control measure for the cecum worm.

FIG. 12.—The cecum worm, *Heterakis papillosa*, from the ceca. (Natural size.) (From Wickware, 1917.)

The California station has also recommended the following procedure to avoid the necessity of fasting with its consequent fall in egg production: Add 2 per cent by weight of tobacco dust containing at least 1.5 per cent of nicotin to the mash, and feed this mixture to the flock for a period of 3 or 4 weeks. Too much nicotin diminishes egg production and too little is relatively ineffective.

If a single-dose treatment is desired for the removal of the large roundworm, the California station reports that oil of chenopodium (oil of American wormseed) is more satisfactory than tobacco. It recommends the use of 1 teaspoon of oil of chenopodium, thoroughly mixed with a moist mash, for each lot of 12 birds.

A treatment which was effective in experiments in the Bureau of Animal Industry in removing the cecum worm from chickens consists in the use of rectal injections of oil of chenopodium in a bland oil, such as cottonseed oil. This treatment will remove about 90 per cent of the worms, thereby greatly diminishing the degree of infestation, and if repeated occasionally should serve, in connection with sanitary measures, as an effective control measure. The dose is 0.1 cubic centimeter of oil of chenopodium in 5 cubic centimeters of cottonseed oil for birds weighing 1½ pounds. Probably double this dose would be effective for a bird weighing 3 pounds or more. This mixture may be made up at the rate of 1 teaspoon of oil of chenopodium in 6 fluid ounces of cottonseed oil and given at the rate of one-third of an ounce to birds weighing 3 pounds or more, using a proportionately smaller dose for smaller birds. The two ingredients should be thoroughly mixed and given with a hard-rubber enema syringe, preferably the infant's size syringe. It is as easy to give this treatment by rectum as it is to give a treatment by mouth. The tip of the syringe should be passed along the floor of the cloaca, which is the common passage into which the intestine and the egg tube open, and the mixture injected slowly.

In connection with the use of these treatments or other treatments, preventive measures along the lines of cleanliness and sanitation should be used. The house and yards should be thoroughly cleaned to reduce the chances of reinfestation from worm eggs and larvæ. The fowls should be moved to temporary quarters, and all droppings and loose dirt, and the surface earth to a depth of several inches, removed. The material removed should be placed where the birds can not get at it, since the eggs it contains are very resistant and may retain their vitality for as long as a year, or possibly longer.

It is important that the yards and runs be kept at all times as clean and dry as possible. Droppings should not be allowed to accumulate, and wet spots and puddles of stagnant water should be drained, or the location of the yards changed to a place which can be kept in a sanitary condition. Under some conditions it may be advisable to change the location of the runs occasionally to put poultry on clean areas. Birds that have abundance of range are less liable to become heavily infested, all other things being equal, than those which have a very limited range.

TAPEWORMS.

There are several species of tapeworms which occur in fowls, and one or more species may be found in many of these birds. These worms are white and flat and are divided into joints or segments. They occur in the intestines and are sometimes present in such large numbers as to cause serious injury or even the death of the infested animal. Some of these tapeworms are rather large and are not easily overlooked, but others are very small (Fig. 13) and may be overlooked unless looked for very carefully. One of the larger worms, known as the spiny-suckered tapeworm (*Davainea echinobothdrida*, Fig. 14), is of especial interest because it produces in the intestine small nodules which closely resemble the nodules caused by tuberculosis. If intestinal nodules are found in birds infested with tapeworms, and if the liver is not affected and other symptoms of tuberculosis, such as lameness, are not present, the condition may be suspected of being due to tapeworms. This may be confirmed by an examination of the nodules on the inside of intestine, after slitting it open, with the finding of the tapeworms attached by the head to the mucous surface at the site of the nodule.

Tapeworms in poultry are especially injurious to young birds and are apparently more prevalent in wet years than in dry years, and in the case of birds kept in damp places than in the case of those kept in dry places. They cause intestinal catarrh, diarrhea, droopiness, loss of appetite, and emaciation.

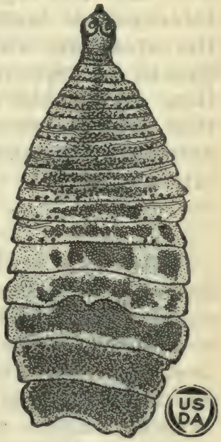
FIG. 13.—The sphenoid tapeworm, *Amœbotænia sphenoides*, from the small intestine. Magnified 22 times. Actual length of worm less than one-fifth inch. (From Meggitt, 1914.)

Treatment.—At the present time it is impossible to make definite recommendations in regard to the treatment of poultry for tapeworms. A number of treatments have been tested in the Bureau of Animal Industry, but no treatment thus tested has been very effective. A method of treatment which has been recommended by the Oklahoma experiment station and has the advantage of being a mass treatment, is as follows:

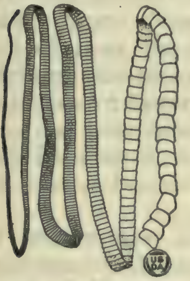
FIG. 14.—The spiny-suckered tapeworm, *Davainea echinobothrida*, the cause of worm nodules on the small intestine. (Entire worm, natural size.) (From Ransom, 1905.)

A gallon of a mixture of wheat and oats, to which is added a small tablespoon of concentrated lye, is cooked slowly for about 2 hours and allowed to cool. The birds are fasted for 15 hours and then given as much of the mixture as they will eat, with plenty of water.

The life history of chicken tapeworms is not known in all cases, but so far as these life histories are known they involve animals other than birds which are the necessary intermediate hosts of the worms. The eggs produced by the tapeworm in the intestine of the chicken pass out in the droppings and are eaten by small invertebrate animals, such as insects, slugs, earthworms, etc., and hatch in these animals, developing to minute larval tapeworms. When these infested insects or other intermediate hosts are eaten by chickens the larval tapeworms develop to the adult tapeworms in the intestines of the chickens. From the nature of these life histories it follows that chickens can not become infested with tapeworms as a result of eating the worm eggs passed in the droppings, as they can in the case of roundworms. It is usually out of the question to prevent birds from eating insects and similar small animals, so that prevention is largely a matter of disposing of the droppings of poultry in such way that the tapeworm eggs in these droppings can not infect the intermediate hosts, or at least can not infect those in the vicinity of the areas on which poultry is kept. To this end the droppings should be removed often and disposed of at some distance from these areas, thus reducing the chance of infecting intermediate hosts that may be eaten by poultry. In general the sanitary measures noted for the control of roundworms are of value for the control of tapeworms.

LICE.[3]

There are at least seven different species of lice occurring on domestic chickens, while still other forms occur on turkeys, ducks, and guinea fowls. As different species of lice are usually confined to different parts of the body, they are commonly referred to as head lice, tail lice, wing lice, and body lice, although the distinction is not very exact, since the various species intermingle to some extent.

Lice powders and their application.—Experiments by the Bureau of Entomology have shown that a very satisfactory way of eliminating lice from poultry is to treat each fowl separately with sodium fluorid. If thoroughly applied one treatment is sufficient. Commercial sodium fluorid may be purchased at most drug stores at from 30 to 60 cents a pound and may be applied either by the so-called "pinch" method, or by means of a duster made by punching small nail holes in the bottom of a can having a tight-fitting cover, or by dipping. If the pinch method is used, the bird is held on a table while sodium fluorid is applied next to the skin under the feathers, as follows: One pinch under the head, one on the neck, two on the back, one on the breast, one below the vent, one on the tail, one on each thigh, and one on the underside of each wing. The feathers should be ruffled to allow the powder to get next to the skin. If the bird is held in a large, shallow pan, the small quantity of powder which falls off will be saved. If the powder is dusted on by means of a shaker the amount of sodium fluorid used may be reduced by using 4 parts of road dust or flour to 1 part of the chemical. This method requires the services of a second person to hold and turn the fowl.

When large numbers of birds are to be treated the sodium fluorid may be used in the form of a dip, using 1 ounce of commercial sodium fluorid to each gallon of water. The birds should be held by the wings and plunged into a tub full of the solution, leaving the head out, while the feathers are ruffled with the hand to allow the solution to penetrate to the skin. The head is then ducked once or twice and the bird allowed to stand a minute to drain and then released. Dipping is just as effective as the other methods, but should be used with care. It is not advisable to dip very weak or young birds, especially in cold or damp weather. The use of the dipping method is advised only during warm and sunny days.

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[3] For additional details see Farmers' Bulletin 801, Mites and Lice on Poultry.

One pound of sodium fluorid will treat 100 birds by the pinch method. Figuring a person's time at 40 cents an hour and the drug at 40 cents a pound, it has been estimated that it costs about $2 to treat 100 fowls.

Another good lice powder is flowers of sulphur, which should be applied with a duster. Although sulphur is considerably cheaper than sodium fluorid, it is less effective against lice and hence must be applied more liberally, so that a treatment with sulphur is in reality more expensive than with sodium fluorid. Many other powders, most of which contain pyrethrum (insect powder) are commonly used, but they have no advantage over sodium fluorid.

Dust baths containing a mixture of tobacco dust or other insecticides and ordinary road dust are often recommended to destroy lice. While it is a good plan to let the birds dust themselves when they wish, no method which allows the bird to treat itself for lice can be expected to eradicate them all, since fowls can not get the dusting powder on all parts of the body where lice are, and many lousy birds will not use the dust bath.

It is possible and practicable to keep a flock of poultry absolutely free from lice and mites, and this should be the aim of every one who is endeavoring to establish a successful poultry industry.

MITES.[4]

COMMON RED MITE.

While there are many kinds of mites affecting poultry, there are three which are of special importance to poultry raisers, the best known being the common chicken mite or red mite (*Dermanyssus gallinæ* De Geer). In the Northern States this mite is dormant in winter, except in chicken houses which are heated, but in the South it breeds and is active the year round, although it is always most abundant in summer. Unlike the other mites affecting poultry, this parasite is found on the birds only when it is feeding. It is nocturnal in habits, feeding at night and hiding during the day in the cracks of the roosts, in the nests, in the corners of the floor, or between boards. For this reason its presence often remains undetected until the chicken houses are badly infested and the poultry raiser seeks an explanation for the drooping condition and listlessness of his fowls.

Treatment.—To eradicate the pest a thorough cleaning of the chicken houses and spraying with a suitable disinfectant having a sufficient body is all that is necessary. All roosts, loose boards, and boxes should be removed and the disinfectant applied in the form of a rather coarse spray, using a suitable pump. One of the best substances for the purpose is anthracene oil. As this is a little too heavy to spray well, it may be thinned with an equal part of kerosene. High-grade creosote also gives satisfactory results. Crude petroleum is almost equally effective and is usually cheaper. It should be thinned by adding 1 part of kerosene to 4 parts of crude oil. Pure kerosene, kerosene emulsion, and carbolic acid are all effective, but as they all lack sufficient body for persistence the spraying must be repeated several times at 10-day intervals. The coal-tar dips, used in a slightly stronger solution than recommended on the labels, will be effective if the application is repeated, and their germicidal properties are a desirable feature. Whatever preparation is used the birds should be kept out of the houses until the fluid has thoroughly soaked into the wood.

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[4] For additional details see Farmers' Bulletin 801, Mites and Lice on Poultry.

DEPLUMING SCABIES.

Fowls and pigeons are sometimes infested by an itch mite which lives at the base of the feathers, causing an intense itching and producing a disease known as mange or depluming scabies. The irritation caused by the mites leads the fowls to pull out their feathers, and they often acquire the habit of feather pulling, attacking the plumage of other birds as well as their own. If the stumps of the feathers are examined soon after the breaking of the quill, they will be found surrounded by scales and crusts, and the adjoining feathers when pulled out will be found similarly affected. In this way the condition can easily be distinguished from molting or the vice of feather pulling, which fowls sometimes acquire without apparent cause. The mites causing the disease are introduced into the poultry yard by affected fowls and spread rapidly from fowl to fowl, finally infesting nearly all in the flock. The disease usually begins in the spring, is most active in warm weather, and largely disappears in winter.

Treatment.—The affected spots of the skin from which the feathers have dropped, and for some distance around them, should be anointed with an ointment made by thoroughly mixing 1 part of flowers of sulphur with 4 parts of vaseline or lard, or 1 part of carbolic acid with 50 parts of vaseline. A convenient liquid preparation is made by mixing Peruvian balsam, 1 ounce, and alcohol, 3 ounces. One of these preparations may be selected and applied at least twice, with an interval of a week or 10 days. It has been reported that both depluming mites and lice may be eradicated with one treatment by dipping in the following solution: Sodium fluorid, ¾ ounce; sulphur, 2 ounces; laundry soap, ½ ounce; water, 1 gallon. The dip should be kept stirred so as to keep the sulphur in suspension.

SCALY LEG; MANGE OF THE LEG.

Another species of itch mite attacking chickens, turkeys, pheasants, and cage birds is the cause of a condition known as scaly leg. While this mite is usually confined to the legs, it may occasionally attack the comb and wattles. The disease occurs in most cases as a result of association with infected birds. It spreads slowly, and many individuals escape it entirely, although constantly exposed to it. (Fig. 15.)

Symptoms.—The disease is easily recognized by the enlargement of the feet and legs and the rough appearance of the surface of the feet. The parasite begins its attack in the clefts between the toes and gradually spreads forward and upward until the whole of the foot and the shank become affected. The two legs are usually attacked about the same time and to the same degree. At first there is only a slight roughening of the surface, but the continued irritation by the mite causes the formation of a spongy or powdery substance beneath the scales, which raises them more and more until they are nearly perpendicular to the surface and are easily detached. In the most severe cases the joints become inflamed, the birds are lame and scarcely able to walk, a joint or an entire toe may be lost, and the birds, unable to scratch for feed, lose flesh and die from hunger and exhaustion.

Treatment.—In the treatment of scaly leg it is advisable to smear the roosts with wood preserver or crude petroleum as a precautionary measure to prevent the further spread of the disease. The uninfested birds should be isolated from the infested, and the latter should have their legs washed with soap and warm water, removing all loose scales. Dry the legs and apply an ointment containing 2 per cent carbolic acid or the sulphur ointment or the Peruvian-balsam wash previously mentioned. Another good remedy well recommended is made by mixing oil of caraway 1 part with vaseline 5 parts, or the caraway oil may be mixed with 5 parts of castor oil and rubbed gently into the skin. Some poultrymen who have large numbers of birds to be treated make a mixture of one-half pint of kerosene and 1 pint of raw linseed oil in a quart can, take it to the poultry house at night, and dip both legs of each affected bird into the mixture, allowing them to drip into the can for a minute after

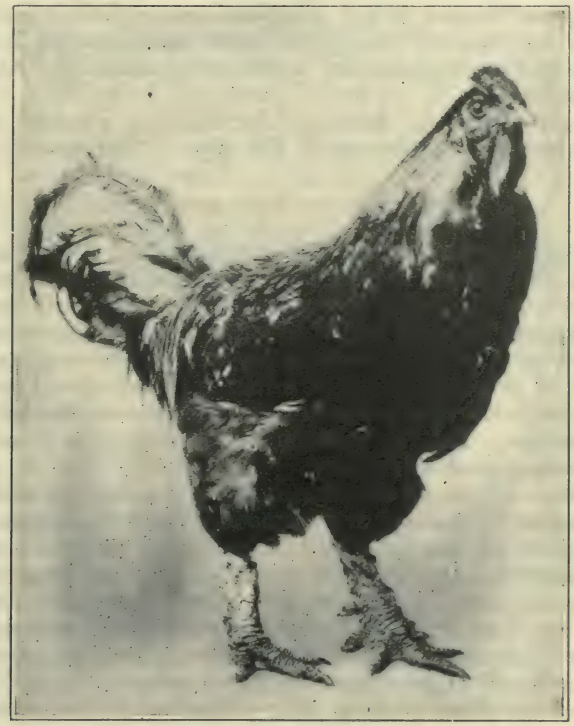

FIG. 15.—Scaly leg.

removal, and then replace the chicken on the roost. The feathers of the leg must not be wet, as it causes irritation and sometimes burns the skin. Crude petroleum is equally effective used in the same way. The treatment should be repeated in three or four days.

OTHER MITES.

Several other species of mites infest poultry. One of these bores into the skin and is found in cysts lying on the under surface of the skin next to the muscles. This form is not known to do any serious injury. Another species occurs in the air passages, liver, and lungs of chickens. Unless present in sufficient numbers to interfere with breathing, it is not a serious pest. Still other mites live among the feathers of the birds, sometimes causing an unsightly appearance of the feathers, but apparently cause little injury to the birds themselves.

Feather mites may be destroyed by dipping affected fowls in the sulphur solution recommended for the treatment of depluming scabies.

CHIGGERS, OR HARVEST MITES.

Chiggers, harvest mites, or "red bugs," which so frequently annoy campers by the intense itching they produce, may also attack fowls. Young chickens having a free range, especially if it includes low-lying lands, are the most liable to suffer from these parasites. The mites penetrate the skin, causing an intense itching, and abscesses may be found where clusters of mites are feeding. These abscesses are sometimes a third of an inch in diameter, surrounded by an area of inflammation. The birds become droopy, refuse to eat, and may die from hunger and exhaustion.

Treatment.—If an abscess has not yet formed the inflamed area may be treated with sulphur ointment, Peruvian balsam, or a mixture of 1 part of kerosene with 3 parts of lard. If suppuration has occurred the scab should be removed and the area washed with 4 per cent carbolic-acid solution. Frequent light dusting with flowers of sulphur will keep the chickens from becoming infested. In the Southern and Central States, where harvest mites are most numerous, it is often necessary to keep young chickens off the range in summer. In these sections it is a good plan to hatch the chicks early in the spring, so that when the warm weather comes, in which the mites are most abundant, the birds will be old enough to resist their attacks.

TICKS.[5]

In some parts of the South poultry are commonly infested with a species of tick known as the chicken tick or adobe tick (*Argas miniatus*). This parasite when full grown may be from one-fifth to one-fourth of an inch long, and is a powerful bloodsucker. In its adult stage of development it has feeding habits similar to the much smaller red mite in that it feeds only at night and spends the day hiding in cracks in the floors or walls. Pigeons are occasionally attacked by a similar tick, and both species have been known to inflict painful bites on persons coming in contact with infested birds.

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[5] For additional details see Circular 170, Bureau of Entomology, The Fowl Tick.

These ticks, on account of their relatively large size compared with mites, can do a great deal of damage in a poultry or pigeon house, and young birds attacked by them are liable to succumb to exhaustion from loss of blood. Moreover, in the case of the chicken tick, it is known that in some countries this parasite may itself be parasitized by minute organisms which are injected into the blood of the fowl which it attacks, causing a severe and usually fatal fever. In this way the tick acts as a carrier of the disease organism much as the mosquito by its bite carries the organism causing malaria to man.

The earlier stages of the chicken tick's development are passed entirely on the body, the tick leaving the birds only when it approaches the adult stage; but thereafter the adult tick attacks chickens only at night, after they have gone to roost.

Treatment.—Chicken ticks are very persistent, and ordinary insecticides have little effect on them. If a chicken house is found to be infested with ticks, the chickens should be removed from it and housed in temporary coops for a period of 10 days at some distance from the chicken yard. This period of quarantine allows the young ticks that are present on the chickens to become engorged and fall off. If the chicken house is badly infested and is not of much value, it should be destroyed by burning. Otherwise, an attempt to disinfect it may be made after all loose boards and boxes which may provide hiding places for the ticks have been removed. Then crude petroleum or wood preservative may be applied as recommended for the treatment of red mites. The temporary coops in which the chickens have been quarantined should be burned or disinfected with boiling water.

A simple and inexpensive way of protecting chickens from the attacks of ticks is to provide readily demountable roosts direct from the floor and not touching the walls, or to suspend the roosts from the ceiling by means of small wires. The roosts are prevented from swaying by similar wires between the roosts and the walls of the house. Nests should be located away from roosting places. If constructed of metal they can be disinfected quickly from time to time by burning out the straw.

Metal houses have been found to be effective in dealing with the ticks, as even without special attention they remain practically tick free, and if necessary they can be disinfected easily by a fire of straw, paper, or other light material, after removal of the roosts. Metal houses, however, are usually more expensive than wooden ones, and are hot in summer and cold in winter. If they are used in summer the fowls should be provided with shade outside the house.

When ticks have once been eradicated from the premises no chickens should be added to the flock until they have been quarantined for 10 days in temporary coops, as already described. The coops should be destroyed after use, or thoroughly disinfected with hot water.

FLEAS.[6]

In the Southern and Southwestern States poultry are frequently infested by a species of flea known as the chicken flea, or stick-tight flea, so called from its habit of remaining attached to one place. This form also attacks dogs, cats, and some wild animals. On poultry the fleas are usually found in clusters on the comb, wattles, and around the eyes; on dogs they are found on the ears. Young fowls when heavily infested often die quickly. Older birds, while more resistant, have been known to succumb to heavy infestations, and even mild infestations will reduce egg laying and retard the growth of the fowls.

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[6] For additional details in regard to chicken fleas see Farmers' Bulletin 683, Fleas as Pests to Man and Animals, with Suggestions for Their Control.

Treatment.—As a preliminary step in the treatment of fleas, all dogs and cats should be kept away from the chickens and should never be allowed to lie on the ground in the chicken yards. As rats frequently harbor large numbers of these fleas and may therefore keep up the infestation, they should be destroyed by trapping, not only on account of the fleas they may carry but because they are themselves a serious pest to poultry. Chicken fleas breed in the cracks of the henhouses, and it is accordingly necessary to treat both the birds and their quarters. The combs and wattles of the birds may be anointed with carbolated vaseline or sulphur ointment. Great care should be taken, however, not to get any of the ointment in the birds' eyes, as it may produce blindness. The henhouses and yards should be thoroughly cleaned out, sprayed with creosote or other suitable disinfectant, and may then be whitewashed with lime and carbolic acid as already recommended for mites.

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FARMERS' BULLETIN No. 1338

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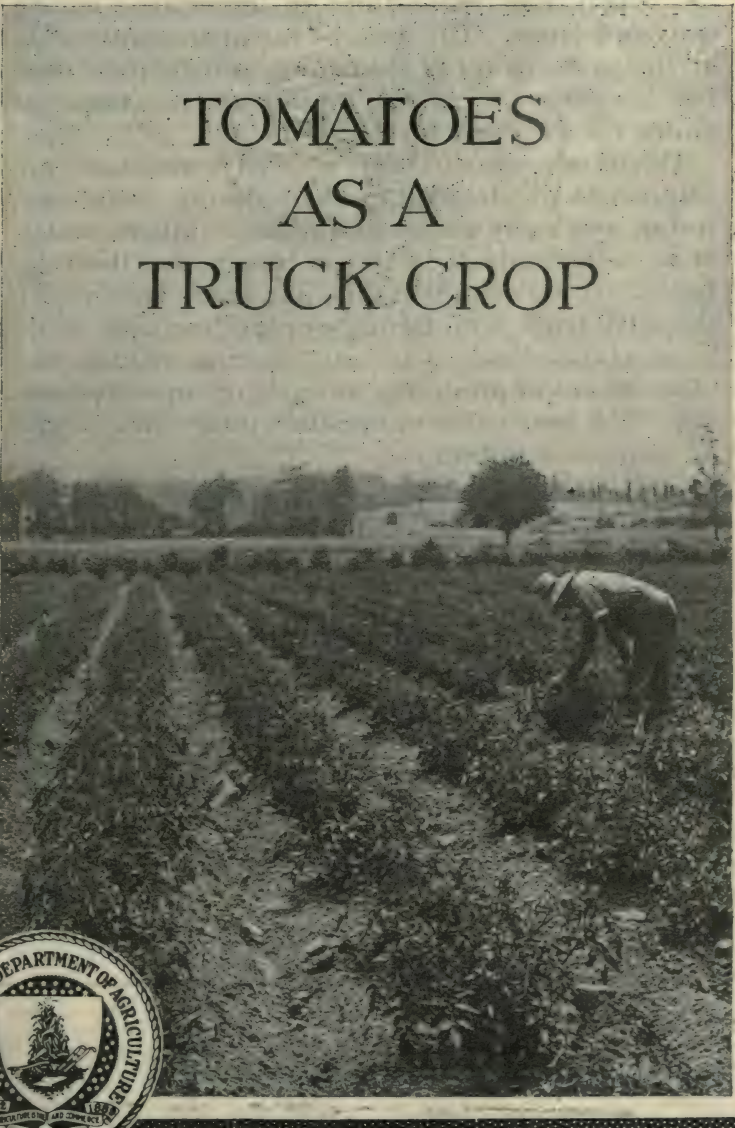
TOMATOES AS A TRUCK CROP



THE TOMATO, a horticultural crop of American origin, now ranks third in importance among our truck crops. The demand for high-quality table or slicing tomatoes is increasing, and there is need for improvement in the quality of the tomatoes grown for the early market.

Thousands of carloads of early tomatoes are shipped to our leading markets during the winter, spring, and early summer from the Southern States, Mexico, Bermuda, the Bahama Islands, and the West Indies. Great quantities of tomatoes are grown as an intensive truck crop throughout the Northern States by special methods of forcing, pruning, staking, and other means of producing an early or superior product. The production of tomatoes under glass is also an important industry.

Suitable soil, good seed, and well-grown plants are the foundation for the production of early tomatoes of high quality, and a number of seed firms are now making a specialty of strains and varieties that are adapted to the work. Marked progress has also been made in the development of strains that are resistant to disease.

Outstanding cases of truck growers who have been especially successful with tomatoes are frequently found, and this bulletin is largely a summary of their methods and results.

Washington, D. C. Issued June, 1923.

TOMATOES AS A TRUCK CROP.

By W. R. Beattie, *Horticulturist, Office of Horticultural and Pomological Investigations, Bureau of Plant Industry.*

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INTRODUCTION.[1]

Fresh or table tomatoes are now to be had in the leading markets of the United States practically the entire year, the supply in the late fall, winter, and spring coming from the west coast of Mexico, Bermuda, the Bahama Islands, Cuba, the Southern States, and the great vegetable-forcing houses of the Northern and Eastern States. The summer and early fall supply comes from the thousands of truck gardens and farms scattered over a wide area, especially in the North-Central and Northern States. According to the 1919 census, the area devoted to early and truck-crop tomatoes in the United States was 120,000 acres, exclusive of those grown for canning and manufacturing. The present need of the early and truck-crop tomato industry is not increased acreage but a general improvement in the growing, grading, packing, and marketing of the crop.

Fresh tomatoes are shipped in car lots from more than 25 States, but the bulk of the early table stock comes from 8 States. The 5-year average for the period ended with 1921 credits Florida with 4,596 cars a year, New Jersey 2,627 cars, California 2,102 cars, Mississippi 1,431 cars, Texas 1,378 cars, and Tennessee 694 cars. Figures are not available to show the great quantities of fresh tomatoes sold locally and those produced in home gardens and used in the homes. The production of early fresh tomatoes in the Southern States is more or less localized, while the general market-garden and truck crop of the North-Central and Northern States is very generally and widely distributed.

In Florida the important early-tomato sections are around Miami and from Boynton to Florida City, around Palmetto, near Lake

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[1] The tomato industry of the United States is naturally divided into more or less distinct branches, according to the use made of the product: (1) The truck and general market-garden crop, including the early table tomatoes grown in the Southern States and those grown for the market throughout the country; (2) the production of tomatoes for canning and for manufacturing; and (3) the production of tomatoes under glass, this latter being simply a special phase of table-tomato production. This bulletin contains information relative to the growing of early, midseason, and late tomatoes for the general market. Farmers' Bulletin 1233 treats of the growing of tomatoes for canning and manufacturing. Farmers' Bulletin 1291 gives information upon the grading, packing, and shipping of early tomatoes. Another bulletin will treat of the growing of tomatoes under glass. Early and truck-crop tomatoes are grown in areas varying from small patches to large acreages, the total for the United States, according to the 1919 census, being about 120,000 acres, exclusive of those grown for the canneries.

Okeechobee, and in the central and north-central parts of the State. In Mississippi the early-tomato industry is located mainly around Crystal Springs and Hazlehurst. In Texas early tomatoes are grown extensively around Alto, Jacksonville, Tyler, and other points in the eastern part of the State. Most of the shipments from California originate near Los Angeles. In Tennessee the towns of Humboldt, Gibson, and Milan hold first place in tomato shipments. Marietta, Ohio, and Anna and Cobden, Ill., are important early-tomato producing points. New Jersey, with the town of Swedesboro as a leading shipping center, supplies the eastern markets with great quantities of midseason fresh tomatoes. In the New England States the market garden tomato industry centers around Boston, Providence, New Haven, Hartford, and other points. Rochester and Buffalo are important centers in New York; and Ashtabula, Cleveland, and Toledo in northern Ohio. In fact, midseason tomato production is highly developed around every important market of the North-Central and Northern States except the extreme Northwest, where climatic conditions are not so favorable for tomatoes.

Exceptional results in the production of fancy table tomatoes are often obtained by members of boys' and girls' clubs and by truck gardeners, who follow the practice of growing 1,000 to 10,000 plants either in pots or in special beds and setting these on one-tenth of an acre to 1 acre of well-prepared land. By this system the plants are set closer than in regular field culture and are pruned to a single stem and tied to stakes or to a trellis. Cases are reported where more than $6,000 worth of tomatoes have been sold from an acre during a season by this method of culture. Results like this are extremely exceptional, however, and are obtained only under the very best conditions.

SOILS ADAPTED FOR GROWING TOMATOES.

Tomatoes may be grown on a wide range of soil types, but a warm, well-drained, and fertile soil is essential for earliness, high quality, and grade. A large part of the southern early-tomato crop is produced on sandy loam soils having a clay subsoil and capable of being worked very early in the spring. Land that is slightly rolling, or which has a gentle slope toward the south or southeast, or which is located where it has the protection of a thick piny woodland or a hill to the north is considered ideal from the standpoint of earliness. In New Jersey, Delaware, Maryland, and others of the Atlantic Coast States truck-crop tomatoes are grown for the most part on sandy loam soils, the selection of the land being made with early maturity of the crop prominently in mind. In the Northern and Mid-Western States tomatoes are planted on almost all types of soil, those of a loamy or sandy loam character being given preference.

Profitable tomato culture is largely dependent upon the soil on which the crop is grown being in the proper physical condition. Heavy soils and those that are poorly drained or which are plowed while too wet seldom yield a profit. Soils that are deficient in organic matter or that are in need of lime are not satisfactory for the production of tomatoes. Plant food can be added in the form of fertilizers, but no amount of concentrated plant food will atone for a run-down and poor physical condition of the soil.

CROP ROTATION.

Crop rotation is a matter of great importance in tomato growing, regardless of soil type or locality. Land on which manure was applied to a cultivated crop the previous season or which has grown a crop of clover or other soil-building crop is preferable. Tomatoes should not follow tomatoes, and the rotation should not include potatoes, peppers, or eggplant, as these are liable to transmit the diseases affecting the tomato. Certain weeds that are closely related to the tomato, such as ground cherry or husk tomato (Physalis) and horse nettle (*Solanum carolinense*), are thought to be carriers of certain tomato diseases, and land infested with these weeds should not be planted to tomatoes. Nematodes, or gallworms, are particularly troublesome on many of the sandy soils of the South and many loam soils of the North, causing gall-like formations on the roots of the tomatoes, as shown in Figure 1. It is impracticable to recommend a definite crop rotation that will be adapted for all localities, but in general tomatoes should be grown in a rotation covering at least four years and including one cultivated crop in addition to the tomatoes and one or more soil-building crops. The important considerations from the standpoint of crop rotation are the avoidance of loss from disease and the securing of high yields and quality. In some localities this may be accomplished by a 4-year or 5-year rotation, but in others a much longer cycle or rotation may be required.

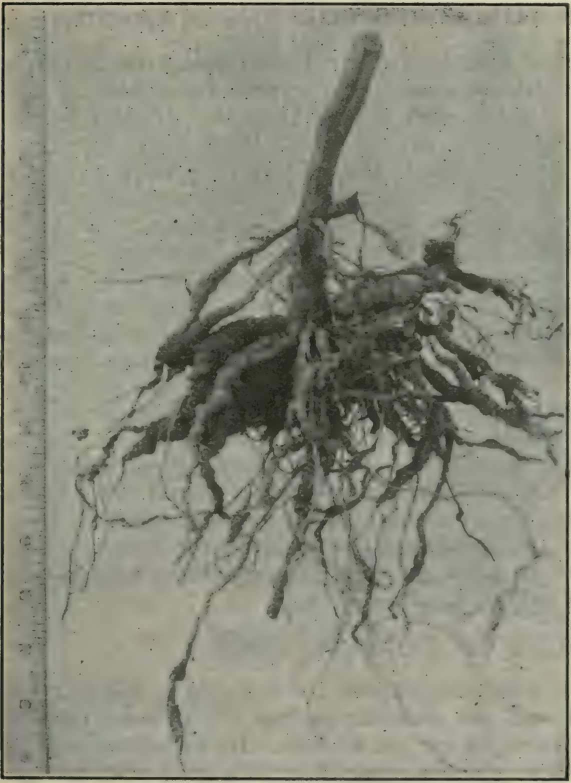

FIG. 1.—Root of a tomato plant affected with root-knot, caused by nematodes, or gallworms.

In Florida the tomato fields are allowed to grow up in heavy grass during the summer, this being either cut for hay or plowed under as a soil-improvement crop. In Texas and Mississippi tomatoes are followed the same season with sweet potatoes, peanuts, velvet beans, or cowpeas. In Indiana, where considerable acreages of tomatoes are pruned and tied to stakes, it is customary to pinch the heart out of the plants after about four clusters of fruit have been formed, and after the early fruit is marketed a hill of Kentucky Wonder beans is planted by each stake and the beans allowed to climb upon the stakes and the old tomato vines. In the New England States the fruiting season for tomatoes usually extends almost until frost, and there is little opportunity for intercropping or the planting of soil-building crops. With a limited supply of manure it becomes necessary for growers to rely more upon soil-building crops and rotations that tend to build up the soil.

VARIETIES OF TOMATOES FOR THE MARKET.

Eight or ten varieties of tomatoes are included in the list for early growing, but the bulk of the southern crop grown for shipment consists of Globe, Acme, Beauty, and Early Detroit. In the North-Central and Eastern States the Bonny Best, John Baer, Earliana, Greater Baltimore, Acme, and Stone are leaders. In California the Stone is most generally grown. Other varieties that are grown in a limited way all over the territory are the Redfield Beauty, Duke of York, Trucker's Favorite, June Pink, Coreless, Delaware Beauty, and Early Jewel. It is estimated that 90 per cent of the Florida crop is of the Globe variety, which, however, often has the fault of being puffy and containing air cavities. Acme and Early Detroit are grown extensively in eastern Texas, and these varieties produce fruit of medium size but very solid. Earliana is not grown to any extent in the extreme South, as its fruits are inclined to be rough, and the yield is not so good as that of some other varieties. In the northern section Bonny Best is one of the leading varieties for staking and pruning. Occasionally a grower is found who has a market for Ponderosa or some similar large variety. Bonny Best, John Baer, and Greater Baltimore are the varieties recommended for northern growing, although a few growers have excellent success with Earliana and Early Jewel.

SOURCES OF TOMATO SEED.

Some seed firms in the United States are making a specialty of high-class tomato seed and are now supplying the greater part of the seed used by the growers of early tomatoes. In a limited number of cases growers are selecting and saving their own seed with marked success, but this is the exception and not the rule. Seed firms growing selected seed under personal supervision are in a position to supply the tomato growers of a given section with seed of a practically uniform strain, thus insuring reasonable uniformity of the product at shipping time. The Florida section is a notable instance where about 90 per cent of the crop is grown from seed of the variety known as Livingston's Globe, the seed, however, not all being furnished by one firm but by several. Another notable instance is that of the California early tomato growers who plant the variety known as Stone, which runs reasonably true to type and strain.

In view of the fact that the quality, strain, and trueness to variety type of the tomato seed used by truck growers have such an important bearing upon the earliness, yield, and uniformity of the crop, no pains should be spared in obtaining the best, and the original cost should be of secondary consideration. The fact that certain growers are paying extremely high prices for specially grown and selected tomato seed, however, does not justify the seed dealer in charging the grower more than high-grade seed of uniform strain is worth on the market. In view of the fact that only about 2 ounces of tomato seed are required to produce plants with which to set an acre, the grower can well afford to pay a fair price, provided he gets the quality he is paying for. In no case should miscellaneous or canning-factory seed be used, but only high-grade seed of known quality. Some growers follow the practice of purchasing their supply of seed a year in advance and testing a small quantity to see that it is true to variety and type. Where this is done special care should be taken to protect the seed from moisture while it is held in storage.

Marked progress has been made by the workers of the United States Department of Agriculture and others in the development of disease-resistant varieties and strains of tomatoes. The effort has been mainly to obtain varieties that are immune to Fusarium wilt, a disease that is especially prevalent in the Southern States. Several varieties have been developed, but the one known as Norton is perhaps the most widely distributed and has given as high as 90 per cent resistance on land where standard varieties proved a failure on account of the presence of wilt. In sections where the wilt does not occur the standard varieties of tomatoes are usually to be preferred. It is recommended, however, that growers having strains of tomatoes particularly adapted to their local needs give special attention to the further perfecting of these, and that where wilt is present one or more of the resistant sorts now available be tried.

METHODS OF STARTING EARLY TOMATO PLANTS.

The profits derived from the growing of early tomatoes are dependent upon getting the product on the market while prices are high, and the first essential to earliness is the production of strong well-grown plants having the first bloom upon them by the time they are set in the open ground. In order to do this the seed should be sown indoors in a small hotbed or in a greenhouse. In Florida, where the growing season is practically continuous throughout the year, the seed is often planted in the field where the plants are to remain, or the seed is sown in a bed where it can be watered and the plants transferred to the field when they attain suitable size. Eastern Texas growers sow the seed in small hotbeds which are usually flue heated and transplant to cloth-covered beds and later to the field. The system followed in Mississippi is similar to that of eastern Texas. The growers of early outdoor tomatoes in the Northern States start the plants in greenhouses or hotbeds and handle them in pots or boxes prior to setting in the open. Some of the most successful northern growers complete the indoor growth of the plants in 6-inch clay pots such as are used by florists. By keeping the plants cool and well ventilated toward the last of their indoor period of growth they become very strong and stocky, having a wonderful root system. In view of the importance of producing good plants for the early-tomato crop, this phase of the work will be discussed under several headings and in considerable detail.

HOTBEDS AND COLDFRAMES.

Hotbeds and coldframes should always be located in a sheltered place, either on a south slope, as shown in Figure 2, on the south side of a building, or where protected by a clump of low-growing pines. Where small native pines are abundant these can be used to create an artificial shelter by planting a temporary hedge of them on the north and west sides of the bed. In eastern Texas and in Mississippi coldframes to which the plants are transplanted are usually located in the center or alongside each acre on which the tomato crop is to be grown. In the Northern States the coldframe is generally located near buildings or on a southern slope where it will get the greatest benefit from the sunshine and be protected from the wind.

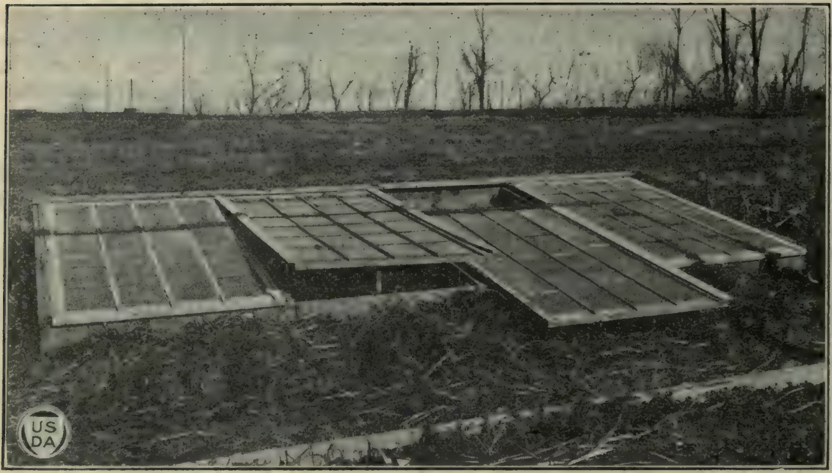

FIG. 2.—A hotbed suitable for starting early tomato plants.

The eastern Texas and Mississippi growers as a rule employ a flue-heated hotbed for starting the seedling tomato plants. This type of bed is constructed by digging a pit about 3 feet deep, 6 feet in width, and 12 or 14 feet in length along the side of a south slope or small hill and as near the house as practicable. A flue is then built the length of the pit, using loose field stones or bricks for its construction. A chimney or metal smoke flue is provided at the opposite end from the furnace, and the pit is covered with a board floor and provided with 10-inch or 12-inch plank or concrete sides. The covering for these beds consists either of sash or of heavy muslin tacked to a roller and supported on crosspieces nailed to the top of the plank sides. Heat is provided by burning stumps, trash, or partly seasoned wood that will give a slow even heat. About 6 or 8 inches of good sifted loam is spread upon the floor of the bed and the seeds planted in rows crosswise of the bed, the rows being spaced about 4 inches apart. In a few instances the plant bed is located alongside the house and heated from the hot-water, steam, or hot-air heating system of the dwelling, but in this case the bed is usually made in the form of a lean-to or pit on the south side of the dwelling, as shown in Figure 3, and is used for other purposes in addition to starting tomato plants.

Manure-heated hotbeds are constructed in the same manner as the flue-heated beds except that the pit for the manure is only about 12 inches in depth and without the raised floor required in the flue-heated beds. The heat is provided by tramping a layer of horse or mule manure in the bottom of the pit to a depth of 6 to 12 inches, according to location, time of winter, and the outside temperature that must be reckoned with. The manure should be reasonably fresh and free from burning or previous expenditure of its heat. Prior to putting it into the bed the manure should be stacked in a low flat pile and turned over once or twice in order to start uniform heating.

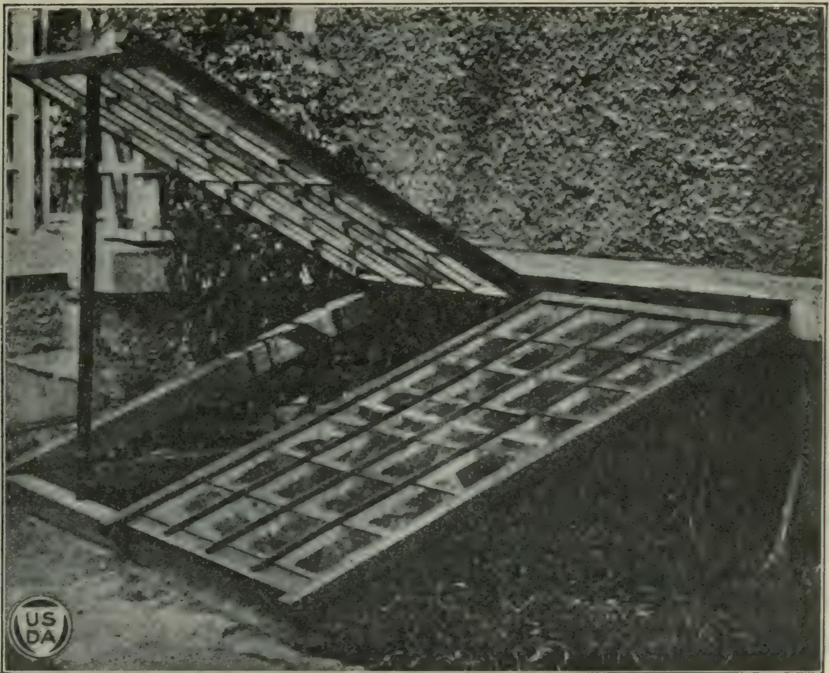

FIG. 3.—Pit attached to a residence and heated by the home-heating plant.

If the manure is very dry, a small quantity of water should be sprinkled over it while being turned. The manure should not be forked into the bed in large masses but should be shaken through the tines of a fork in thin even layers all over the bed. As each layer is spread it should be tramped moderately, and after the placing of the final layer the entire bed of manure should be well tramped. Following the placing of the manure in the bed, about 6 inches of good sifted-loam soil should be spread over the entire surface. A manure-heated bed should be made several days before the date for sowing the seed, in order that it may heat to its highest point and the temperature recede to 85° F. or lower before the seeds are sown.

The coldframe in most general use by the growers of Texas and Mississippi is 10 by 60 feet in size, with a ridgepole through the center, sloping ends, strips or rafters to support the cover, and 8 to 10 inch boards for the sides. As a rule the bed is located right on the land where the crop is to be grown, one bed of the above specified size setting 5,400 plants 4 by 4 inches, or enough plants to set 1 acre. The covering for these beds consists of heavy unbleached muslin sewed together to form a large sheet. This is spread over the bed and fastened to the ridgepole by nailing a strip of wood over it. The edges of the sheet are clamped between two strips of wood running the full length of the bed and forming rollers upon which to roll the sheet to the ridge from either side. The ends are held down by loops of tape sewed to the sheet and fastened over nails driven into the ends of the bed. A good idea of a bed of this type can be gained from Figure 4. As an added precaution against a sudden drop in temperature a quantity of light prairie hay or pine straw is provided, and if necessary this is spread over the sheet to a depth of 2 or even 3 inches. In removing the straw covering a large broom is used. In some instances it has become necessary to hang lighted lanterns inside the frames during cold nights.

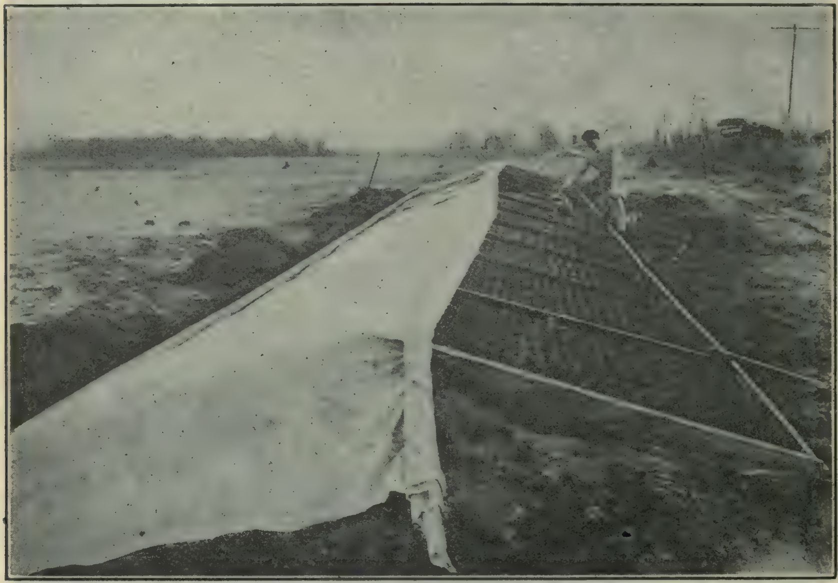

FIG. 4.—Type of coldframe used by the tomato growers of Texas and Mississippi for growing early plants after starting the seedlings in the hotbed.

Many of the growers of early tomatoes in the section lying too far north for the use of the cloth-covered coldframes but not so far north as to require great protection for their beds have found the use of hotbed sash and straw mats sufficient. Usually the beds are well banked on the outside with fermenting manure to keep out the cold.

A number of growers of early tomatoes in New Jersey have provided permanent concrete beds which are heated by means of hard-coal burning hot-water boilers and a system of pipes under and around the bed. The usual custom is to place the heater in a pit at one end of the bed or often in the basement of an outbuilding to which the bed is attached. These beds are often made 20 by 40 or 20 by 60 feet in size and are used mainly for starting sweet-potato plants, a small portion only being used for tomatoes. The covering for these beds is either heavy muslin, light canvas, or sash. The heater pipes are carried from the boiler through the center of the bed and return around the outside. In a few cases heater pipes are either buried in the soil or run through 3-inch tiles laid in the bottom of the bed and covered with a foot or more of soil. The first cost of a bed of this character is high, but if properly built it will last for a great many years and is very effective and economical in its operation. A bed of this type is shown in Figure 5.

In the Northern States, where greater protection is necessary, the growing of plants requires the use of greenhouses or heated frames. A brick or concrete pit 18 to 24 inches in depth covered with ordinary hotbed sash and located along the south side of a greenhouse from which it can be heated is perhaps the ideal method of growing early tomato plants.

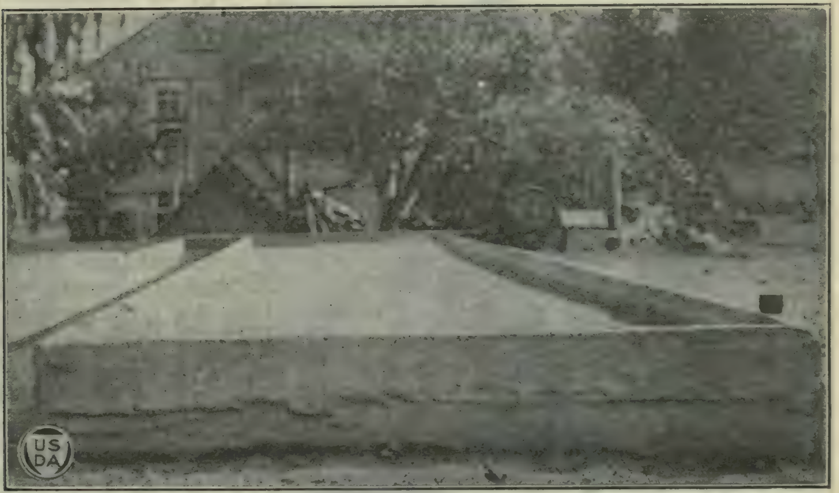
FIG. 5.—Permanent concrete bed provided with hot-water heater used by a New Jersey grower for starting early plants. The heater is located in the basement of the building in the background.

One of the most successful growers of early tomatoes in northern Massachusetts finishes his tomato plants in 6-inch pots in a low greenhouse formerly used for growing cucumbers. This house has both top and side ventilation, making it possible to grow stocky plants. A tomato plant of this type is shown in Figure 6. To produce 8,000 to 10,000 such plants will require a space 8 by 8 inches for each, or 4,000 square feet of bed space. By using 5-inch pots and crowding the plants a little 10,000 plants can be carried on 2,500 square feet of bed surface, but it should be borne in mind that in order to grow good plants plenty of space must be provided.

GROWING TOMATO PLANTS.

Tomato seed sown in a hotbed in eastern Texas or in Mississippi from January 28 to February 15 will produce plants for setting in the field in six to eight weeks; usually in about 50 days. Some growers plant the seed earlier than this, but it is better to keep the plants growing rapidly from the start rather than have them too early and then become checked. The time of sowing seed, however, will vary with the locality and must be determined by the time that the plants can be set in the field. The seed should be sown in rows about 4 inches apart, 6 or 7 seeds to the inch, and covered half an inch deep. After the seeds have been covered the surface of the soil should be watered with a sprinkling can, being careful to distribute the water uniformly over the bed. This watering will settle the soil about the seeds and also supply the necessary moisture to sprout them. During bright days a bed that is covered with sash will heat very quickly, and it will be necessary to ventilate either by sliding the sash partly off the bed or by tilting the side opposite to the wind. In the case of a cloth covering, it should be rolled part way up or lifted on the side opposite the wind. Toward evening the bed should be closed, so as to retain the heat for the night. Watering should be done only when necessary, as excessive or careless watering will cause the plants to damp-off at the surface of the ground or make a soft growth. Watering should be done early in the day, so the plants will dry off before the bed is closed for the night. The seed bed should not be allowed to dry out, but great care must be exercised both as to the quantity of water and the time of applying it. The usual practice is to have a barrel or two of water at the plant bed and apply the water as needed, using an ordinary 10 or 12 quart sprinkling can.

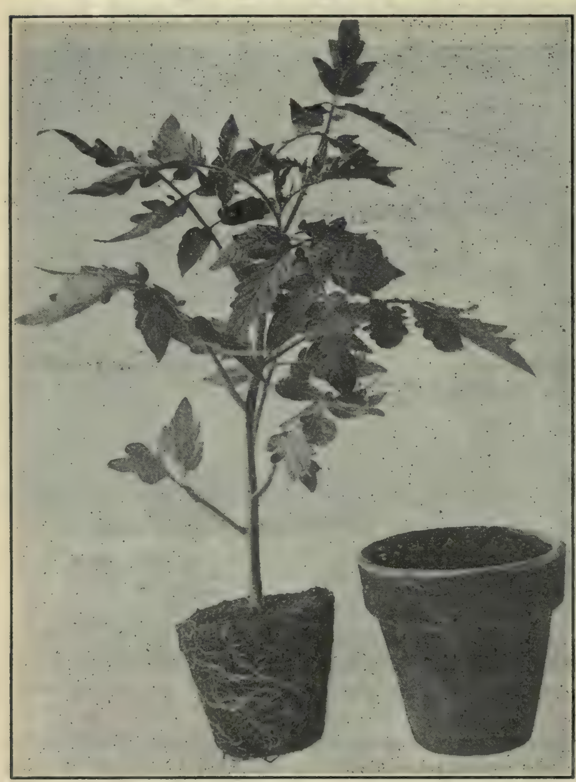

FIG. 6.—A good pot-grown tomato plant ready for setting in the field.

Work should be started on the preparation of the coldframes immediately after sowing the seed in the hotbed. If these beds are to be located in the field, the land should be first plowed, then the framework put in place. The next step is to scatter about 10 quarts of fertilizer over the surface of the 10 by 60 foot bed and work this into the upper 4 inches of soil with a spading fork. The bed should then be left to settle for several days, or until the plants in the hotbed are ready to transplant. A day or two before transplanting begins the muslin cover should be fastened on the bed and the surface of the soil raked to a smooth, fine texture. Two or three barrels of water should be hauled and placed at a convenient point alongside the bed; also about two loads of marsh or prairie hay or its equivalent in pine straw should be piled near the bed. Two boards 1 inch thick, 12 inches wide, and just a little less than 10 feet long, so that they will drop into the bed crosswise, will be required to work upon while setting the plants. A row of small pegs, 4 inches apart, nailed to the edge of one of these boards will serve as a marker and form the holes in which to set the plants. Some growers, however, prefer to have a separate marker consisting of a 1 by 3 inch lath to which the pegs are fastened, as better openings in the soil are made with this type of marker than with the board.

Tomato seedlings will be ready to transplant from the hotbed to the coldframe in 12 to 18 days after sowing the seed, depending upon the amount of sunshine and the care given the bed. The plants first have the two seed leaves with which they come through the ground. A day or two later the first regular leaf begins to develop, and when the plants have their second regular leaf in addition to the seed leaves they will be ready for transplanting. The hotbed should be ventilated freely, or the covering removed entirely on bright days, to harden the plants before transplanting. A calm cloudy day is preferable to a windy bright day for transferring the plants from the hotbed to the coldframe. Before starting to lift the plants they should be watered, so that the soil will adhere to their roots. The plants should be lifted carefully by running a trowel or a thin paddle under them and placed in shallow boxes for transferring to the coldframe.

Tomato plants should be set in the coldframe about an inch deeper than they stood in the soil of the hotbed. Special care should be taken to see that the soil is well firmed about their roots and that the tops stand straight and uniform. Water should be sprinkled over the plants as fast as the rows are set, the quantity applied depending upon the moisture content of the soil. If the soil of the coldframe is too dry it should be watered the day before transplanting, but due consideration should be given weather conditions, as showers are liable to occur frequently at that time of the year. Two men can easily transplant one coldframe in a day if everything is in readiness.

Following transplanting, the tomato plants should be kept well shaded with the cloth covering for a day or two until they recover. In case the sunshine is bright the cover should be raised along the edge, but the plants should not be subjected to strong wind. During cold or rainy weather the covers are kept battened down tight to the frames, and in case of freezing, the straw covering is put on early in the afternoon. During bright weather the curtains are rolled up, usually on one side only at first, in order to protect the plants from the wind. The object of the grower is to keep the plants growing strong and stocky right from the first and to avoid extremes of temperature or moisture conditions. As the time for setting in the field approaches, the covering is kept off most of the time to harden the plants to outdoor conditions.

In the North-Central States the tomato seed is sown in flats in the greenhouse from February 20 to March 10. The plants are first pricked off into other flats and later into pots, or they are handled in 2-inch pots at first and then shifted to larger pots as growth and root development proceeds. Tomato plants grown in pots are liable to become root bound, and it is often necessary to shift to pots as large as the 6-inch size in order to prevent serious checking of the growth. One-quart berry boxes are sometimes used as containers for early-tomato plants; also paper pots, paper bands, and wood bands. Pieces of inverted sod are sometimes used as a base for growing the plants, these being transferred to the field with the plants. Clay pots give the best results, but these are not normally practicable for use on a larger scale than for planting 2 or 3 acres.

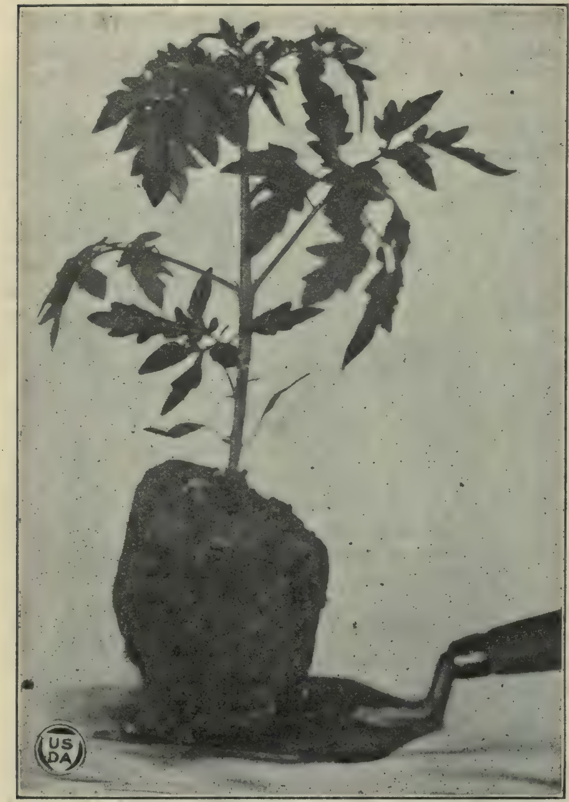
FIG. 7.—A good transplanted tomato plant ready for setting in the field.

Watering pot-grown plants requires skill and frequent attention, in order that the soil may neither dry out nor become waterlogged. A good plan in potting the plants is to place a few pieces of a broken pot on some small stones over the drainage hole in the bottom of each pot. This will insure good drainage and aeration of the root system. Paper pots require even greater care than clay pots to avoid overwatering.

The proper spacing of the potted plants on the greenhouse bench or in the coldframe is of vital importance in the production of strong stocky plants. Where the plants are transferred directly into the soil of the coldframe they should be given at least 4 inches in each direction and then set in the field before they crowd each other. A plant grown in a coldframe and in proper condition for planting in the field is shown in Figure 7.

PREPARATION OF LAND.

Land on which tomatoes are to be grown is usually plowed three or four weeks before time to plant, in order to give opportunity for thorough preparation and for the application of manure and fertilizers. In a few cases the land is plowed in the fall and left exposed over winter. Thorough and reasonably deep plowing is essential, and where any grass is to be turned under a chain or colter should be used in order to cover it completely. The greater part of the harrowing and pulverizing work should be done shortly before planting, however, the preparation of the soil depending considerably upon the kind of fertilizers or manure used and also on the locality and the method of growing the crop. No special tools other than the regular plows, harrows, and cultivators of the ordinary farm are required for growing a crop of tomatoes. One of the most important tools, in addition to the plow, is a disk harrow, with which to cut and pulverize the soil. Some of the best tomato growers follow the practice of disking their soil four to six times previous to planting.

MANURES AND FERTILIZERS.

Practices governing the use of manures and commercial fertilizers for tomatoes vary with the locality and the soil. Many growers prefer to apply manure to the crop preceding tomatoes rather than to the tomato crop itself. The growing period of the tomato is comparatively short; therefore, it is necessary that its plant-food supply be in a quickly available form, and this is not the case with fresh manure. Moderate quantities of well-rotted stable manure may be applied in the rows or worked into the soil for the early tomato crop, but should be supplemented with readily available plant food in the form of fertilizers. The application of large quantities of stable manure is liable to produce excessive vine growth at the expense of the setting of early fruit.

Coarse or fresh manure as a rule should not be worked into the soil in preparing for planting tomatoes, but if used it should be applied six months or a year in advance, preferably in connection with a crop of corn or some heavy-feeding crop. By this method the manure will become thoroughly decomposed and mixed with the soil before the tomatoes are planted. Compost, or rotted manure, may be applied to advantage on most soils at the rate of 4 to 6 tons to the acre in the furrows or 8 to 10 tons if broadcasted. Where the manure is applied in furrows under the rows it should be thoroughly mixed with the soil by means of a single-shovel plow or a narrow cultivator. A double furrow is then thrown over the manure, making a sort of bed, which is leveled with a plank drag just before setting the plants. Growers of staked and pruned tomatoes sometimes apply a mulch of about 2 inches of fine, strawy manure about the plants. This not only holds moisture but keeps down weeds and supplies the plants with considerable plant food.

Practices involving the use of stable manure for growing tomatoes in the southern Florida district, especially around Miami, are decidedly different from those described above. In that section the land is extremely wet during a portion of the year, and it is often a problem to get it dry enough for early planting. In order to overcome this difficulty a small quantity of manure is placed under each plant. This manure provides a dry footing for the plant, improves the drainage of the soil immediately under and around the plant, and at the same time provides food for the early growth of the plant.

Commercial fertilizers play an important part in the growing of the southern early-tomato crop, from the fact that manure is scarce and fertilizers give the plants a supply of quickly available plant food. The quantity and composition of the fertilizers, however, vary under different conditions. A formula in common use contains 4 per cent nitrogen, 8 per cent phosphoric acid, and 4 to 6 per cent potash. Some growers use a formula of 2–8–2, such as is used for cotton and corn, then top-dress with 150 to 250 pounds of nitrate of soda to give the plants a rapid growth. In Florida a 5–5–5 fertilizer is sometimes used, in some cases a 4–8–6 formula being employed. The quantity of commercial fertilizer applied by the Florida growers varies from 800 to 2,000 pounds per acre, the rule being 1,200 or 1,400 pounds to the acre.

With the present scarcity of manure, the market gardeners of the Northern and Eastern States are coming to depend more and more upon commercial fertilizers. The quantity applied and its composition vary with the locality, but most of the tomato growers of the northeastern section are applying 800 to 1,400 pounds of a fertilizer having an analysis of 3 to 4 per cent nitrogen, 8 per cent phosphoric acid, and 6 per cent potash.

Commercial fertilizers are in some cases sown broadcast over the entire surface, but as a rule from one-third to one-half the total quantity is sown in the rows and the remainder broadcasted. Where all the fertilizer is applied in the rows under the plants special care must be taken to mix it thoroughly with the soil to avoid injury to the plants. On land on which 8 to 10 tons of rotted manure has been broadcasted or 4 to 6 tons placed under the rows it is customary to mark off the rows with a 3-row or 4-row marker, then distribute the fertilizer in a strip about a foot in width along the row, using a 1-horse fertilizer distributor with a fan-shaped device underneath to spread it. The fertilizer is then mixed with the soil by means of a cultivator.

In the southern Florida tomato district commercial fertilizers are applied throughout the growing season. Where only one side of the row is cultivated, as is often the practice, the fertilizer is applied in small furrows. First, about a week or 10 days after the plants are set a handful of fertilizer is placed on one side of the plant and generally left uncovered. Ten days or two weeks later more fertilizer is applied between the plants in the original planting furrow. A shallow furrow is then turned over this fertilizer. This forms a support for the plants. The third application is placed in the furrow made when the second application is covered. As many as five applications are made in this manner, the fertilizer being applied just beyond the feeding roots with a view to keeping the plants constantly supplied with plant food.[2]

Where nitrate of soda is applied as a top-dressing, not more than 150 pounds should be used to the acre at one time, and not more than two applications should be made. The first application should be made about 10 or 15 days after the plants are set in the field and the second one, if made at all, about the time that the plants have set their fourth cluster of fruit. The nitrate of soda should not come in contact with the plants, nor should it be scattered too closely about their roots but uniformly distributed over a strip of ground about a foot wide on either side of the plants and cultivated into the soil.

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[2] Sando, Charles E. The process of ripening in the tomato, considered especially from the commercial standpoint. U. S. Dept. Agr. Bul. 859, 38 p., 3 fig., pl. 3–4. 1920. Literature cited, p. 32–35.

PLANTING IN THE FIELD.

Tomato plants should not be set in the open ground until danger of frost is over. Many growers make the mistake of setting their plants a little too early, and as a result they are injured by cold and checked in their growth. While it is true that well-grown tomato plants will often go through a temperature of 1 or even 2 degrees below the freezing point, they are certain to be injured by such exposure, and it is best to wait until the weather and soil are reasonably warm before setting out the plants.

In eastern Texas planting in the field is usually done about the first or second week in April. Occasionally the season is so far advanced that the plants can be put out the last week in March, but April 10 is considered the frost-free date for that section. In Mississippi the season is usually 10 days later. In northern sections the time for outdoor planting varies with the location, but for the most part ranges from May 1 to 15, May 10 being considered the ruling frost-free date for the region in which these early tomatoes are grown. As 3 to 5 acres constitute about the average area planted by an individual grower in Texas or Mississippi, it is possible to handle the entire setting in the field within a week's time; in fact, it is desirable to have the setting all done within a short period, in order that the fruit may mature at the same time. In Florida, where acreages are much larger, planting begins in the late autumn for winter fruiting, but as a rule the big planting is made in January. The product of this goes upon the market during the spring months, ahead of the Texas and Mississippi crops.

Too much stress can not be placed upon the importance of having the soil well prepared before starting to plant. Under the term "preparation" are included plowing, harrowing, the application of manure and fertilizers, as previously described, and finally the opening of the furrows or the holes in which the plants are to be set. Where the manure and fertilizer have been placed directly in the rows it is customary in disking or harrowing to leave 3 or 4 feet of the original mark at the ends of the field as a guide for relocating the rows at planting time. A single-shovel plow or a very small turning plow is generally employed for opening the rows ahead of the planting. Another method is to mark the field in both directions with a 3-row or 4-row marker and then set the plants in the intersections with planting trowels. In a few cases the plants are being set with transplanting machines the same as are used for tobacco and sweet potatoes.

PLANTING DISTANCES.

Planting distances vary with the locality and the method of cultivation. The usual planting distances in the Texas and Mississippi districts are 3½ feet between the rows, with the plants 24 to 30 inches in the rows. At 30 inches in the row approximately 5,000 plants will be required to set an acre. In Florida, where the plants are not pruned or tied to stakes, the planting distances are 4 by 4 feet, although some growers plant 3 by 4, 4 by 5, and various other distances.

In the Miami district the tomato plants are frequently set 2 to 3 feet apart in rows that are 6 feet apart. Another method is to have a 6-foot space between two rows, then a 2 or 3 foot space, the narrow row being allowed to grow to weeds, which partially support the plants of the two rows. While this method may prove reasonably satisfactory under conditions in the Miami district, it can hardly be considered a good cultural practice.

About 3,000 plants to the acre are required for planting according to Florida methods, the land being marked in both directions and cultivation conducted both ways until the plants begin to cover the ground. In New Jersey the plants are set 3 by 4 or 4 by 4 feet apart. Where tomatoes are grown by the most intensive pruning and staking methods, as for example in the New England States, the plants are set in double rows 18 inches apart each way with a 3½-foot space between that and the next double row. By this method 8,000 to 10,000 plants are set on an acre.

SETTING THE PLANTS.

The plant bed should be thoroughly watered a few hours before the plants are lifted. Where a hose is not available it is a good plan to have two or three barrels of water alongside the bed, and while the plants are being lifted the soil should be kept reasonably wet so that it will adhere to their roots. In Texas and Mississippi, where the plants are grown 4 by 4 inches apart in the coldframe, a large knife or trowel is used to cut between the plants in both directions. A square-pointed or planting trowel is used for lifting the plants, and they are taken up with a block of earth about 4 by 4 by 5 inches in size adhering to their roots, as shown in Figure 7. As the plants are lifted from the bed they are placed upon small board platforms about 30 by 30 inches in size having handles extending at both ends so that two men can carry them. These carriers hold about 40 plants each and are carried or hauled to the place where the plants are to be set. In the case of the field coldframes used in the Southwest, the sides and framework of the bed are removed before beginning to lift the plants, as shown in Figure 8. When the area has all been set except that occupied by the coldframe, this space is replowed, the rows extended through it, and the plants set so that they become a part of the field, the framework and coverings of the bed being hauled to the barn and stored until the following year.

Everything should be in readiness for planting and the crew organized the day before the plants are to be set in the field. In the tomato fields of eastern Texas it has been found economical to have a crew of seven or eight persons to do this work. The equipment for planting should consist of a horse and small plow to open the furrows, a claw hammer and pinch bar for removing the coldframe, a sprinkling can and two or three barrels filled with water, three or four planting trowels, five or six platforms or shallow trays for carrying the plants, two hoes for filling the soil about the plants, and a cultivator with which to cultivate the soil between the rows after the plants have been set. Wheelbarrows are sometimes used for carrying the plants from the bed to where they are to be set, but have the disadvantage that in wheeling them over the plowed ground the shaking loosens the soil from the roots of the plants. The horse or mule used for opening the furrows, if a quiet one, may be left standing at the end of a row when not needed. One man opens the furrows as required and waters the plant bed; one or two men lift the plants from the plant bed and place them on the carriers, as shown in Figure 8. Two men are required to carry the plants from the bed to the field where one or two persons take them from the trays and set them in the ground, placing a little soil around each plant, as shown in Figure 9. The plants should be set about 2 inches deeper in the field than they were in the plant bed. One or two men follow the plant setters with hoes and draw the dirt about the plants. Immediately upon the completion of the setting the field is cultivated and the soil worked well around the plants.

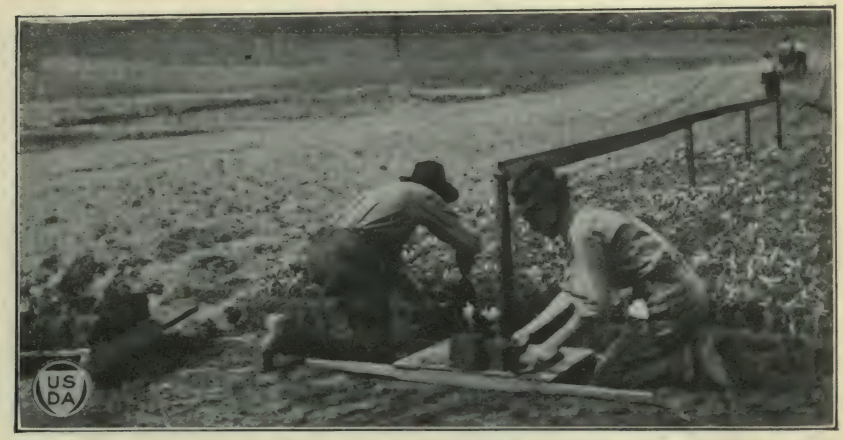

FIG. 8.—Removing tomato plants from a coldframe for setting in the field.

In case the plant bed is located at a distance from the field, low flat-top wagons are used for hauling the plants to the field, and as they are lifted from the bed the plants are placed in shallow boxes or on board forms about 24 by 30 inches in size, these being constructed of light material so as to be easily handled. These boxes or forms are placed on the wagon, which is driven through the field, and the plants taken from the wagon as they are set. By this system three or four hands can make fair progress setting the plants. If the land is very dry and it is necessary to water the plants as they are set an additional team and two laborers will be required.

In setting pot-grown plants the most rapid progress can be made by removing them from the pots at the plant bed, this being done by inverting the pot and jarring its edge on the side of the bed or something reasonably solid. The plants are then packed in trays and hauled to the field. This method works very well where the plants have formed a matted-root system, but when the plants have not formed sufficient roots to hold the ball of earth together it will be advisable to transport the plants to the field in the pots, removing them as the plants are set. Plants grown in berry boxes are taken to the field in them, and when ready to set a knife is used and the boxes are cut away from the roots of the plants.

CULTIVATION.

Tomatoes require frequent shallow cultivation, especially during the first four weeks of their growth in the field. The surface soil should be loosened as soon as it is dry enough after every rain. Hand hoeing between the plants in the rows is necessary after practically every cultivation, and all weeds should be kept out, as they not only rob the soil of plant food and moisture, but certain weeds are carriers of diseases that attack the tomato. The tools required for the cultivation of tomatoes consist mainly of the types used in general farm and garden cultivation. Riding cultivators, such as are adapted for cultivating corn, are often used in the fields prior to the time that the tomato plants begin to spread over the ground. Where the plants are check planted cultivation can be maintained in two directions, thus almost entirely eliminating hand hoeing. In eastern Texas and in Mississippi 1-horse cultivators and sweeps are employed for the most part. An A-shaped cultivator having about 14 small teeth or a standard 5-shovel cultivator with two or three sizes of shovels will answer every requirement. Care must be taken to avoid deep cultivation near the base of tomato plants trained to stakes or other forms of support, as the feeding roots run close to the surface and there is not the protection and shading of the vines that are afforded where they spread naturally upon the ground. As already mentioned, a number of the northern growers of early tomatoes place a mulch consisting of about 2 inches of fine straw-

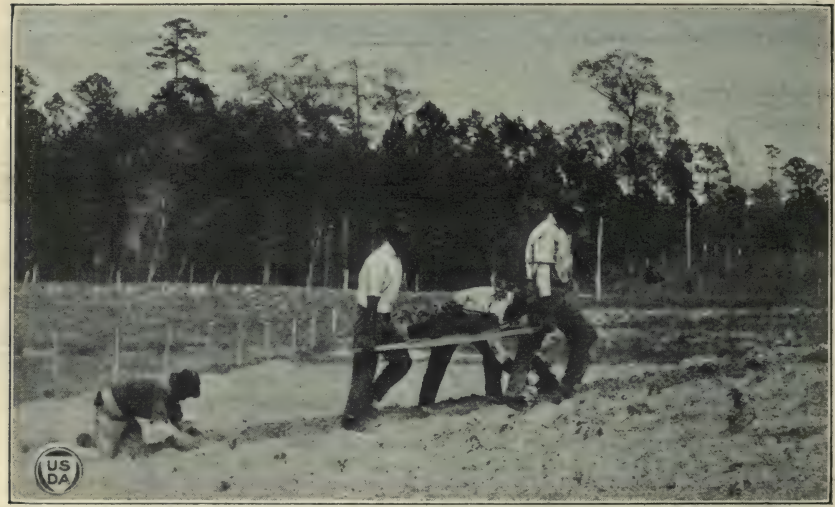

FIG. 9.—Setting coldframe-grown tomato plants in the field.

bedding manure along the rows. This mulch not only retains moisture but stimulates the growth and protects the shallow root system of the plants from the heat of the sun.

Cultivation of the tomato crop is discontinued by the growers in eastern Texas and in Mississippi about the time they begin to pick fruit. In case of a heavy rain during the picking period, which extends over a period of four or five weeks at most, a cultivator is sometimes run through the middles of the rows to loosen the surface and hold the moisture. New Jersey growers keep up cultivation until the vines begin to cover the ground, making further cultivation without injury impossible. Where irrigation is practiced by the growers of fancy tomatoes at the North, the soil is cultivated within a few days after each watering. Where tomatoes are pruned and tied to stakes in the home garden or club garden a wheel hoe is ideal for cultivation. The main point of cultivating tomatoes is to keep the surface soil loose and mellow and the ground entirely free from weeds.

IRRIGATION.

Irrigation of early tomatoes is not practiced to any great extent in the Southern and Eastern States. Market gardeners of the North-Central and Northeastern States, however, frequently plant an acre or two of tomatoes under overhead irrigation. The moisture requirements of the tomato are such that artificial watering is seldom necessary in humid regions during seasons of normal rainfall. During excessively dry seasons, however, the gardener who has irrigation facilities and applies a moderate quantity of water will be in the market late in the summer when tomatoes are bringing a good price. Knowing when and how much water to apply to the tomato crop is the determining factor in the matter of irrigation, as an excess of moisture often does more harm than good.

In arid or semiarid districts the usual method of applying water to other crops may be used for tomatoes. Care must be taken, however, to avoid overwatering, causing the shedding of the blossoms. Subirrigation by means of lines of tiles laid about 18 inches below the surface has been found ideal for tomatoes, as this method permits the application of water to the roots while the surface soil remains dry. Where tomatoes are watered on the surface of the ground it is essential that proper cultivation and the loosening of the soil should follow.

STAKING AND PRUNING.

Growers of early tomatoes in Texas, Mississippi, and a number of other sections in the Southern States follow the practice of pruning the plants to a single stem and tying them to stakes. The growers of Florida and southern Georgia, where the acreages are much larger, still allow the plants to grow naturally upon the ground, however, though some are trying the staking and pruning method on a small scale. The growers of the Northeastern States frequently prune and tie an acre or two, but most of the tomatoes grown for the markets of this section are left upon the ground. In a few northern sections tomato growers follow a practice known as "leaf pruning," but grow the plants in the usual manner upon the ground.

The stakes used by the southern tomato growers are either split from pine logs, cut from sawmill edging, or consist of small saplings cut in the woods. They are usually 3½ to 4½ feet long and sharpened at one end so they may be easily driven into the ground. The stakes should be gotten out during the early winter and hauled to the field where the tomatoes are to be set. It is customary to choose a straight-grained pine tree, cut it into sections of the desired length, and then split it into slabs or bolts that are easily handled. A double-bladed ax is then stuck firmly into the stump and the stakes split by striking the slabs upon the exposed blade of the ax. In this way the stakes are gotten out very rapidly.

Immediately after the plants are set a stake is driven beside each, the stakes being kept in line in the row and about 3 inches from the base of the plant, as shown in Figure 10. Wooden mallets are generally used for driving the stakes, to avoid splitting them. The tying of the tomato plants to the stakes should begin immediately and be repeated every week or 10 days until about four tyings are made. Soft jute string, known in the tomato regions as "tomato twine," is used for tying. This string comes in large twisted hanks and can be cut off in short sections of about 9 or 10 inches as required. Raffia is also used extensively for tying tomatoes, especially by the northern growers. In tying, the string is passed around the stake and crossed between the stake and the stem of the plant, as shown in Figure 11. The roughness of the stake is generally sufficient to prevent the soft jute string from slipping down, and the stems should be drawn up close to the stakes. It is a good plan to form the tie just below a leaf, but this is not essential.

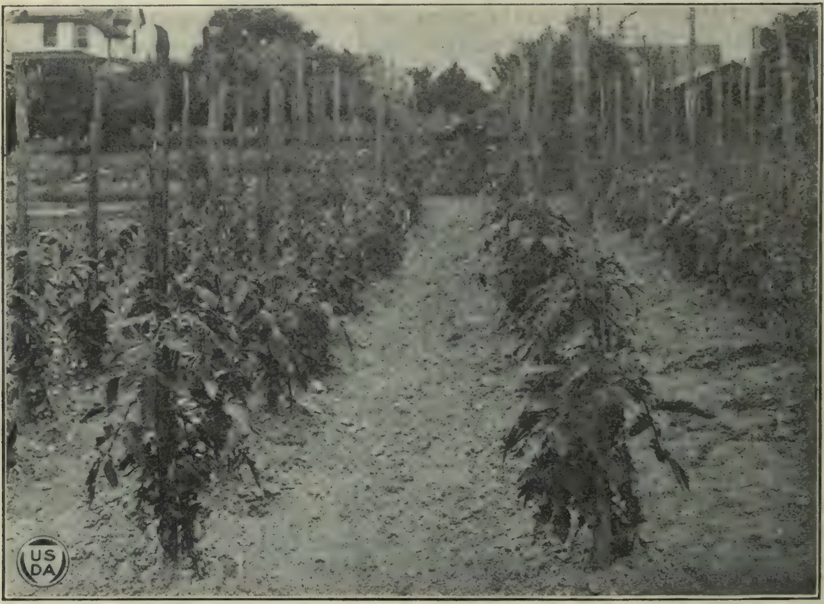

FIG. 10.—Tomato plants being grown by the pruning and staking method.

Early-tomato growers of the northern sections employ various methods of supporting the plants. Some use stakes 5 to 6 feet in length driven into the ground, others employ light bamboo stakes and tie them to wires at the top, as shown in Figure 12, while other growers use a regular trellis of posts and wires, as shown in Figure 13. The growers around Boston as a rule prune to two stems and tie to heavy strings which are supported by overhead wires. Many of the growers of the Central States use a combination of posts, wires, and lath stakes to support their tomatoes.

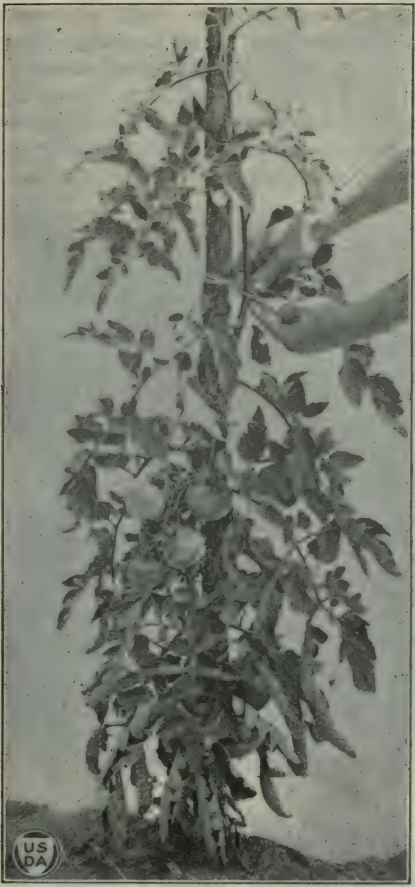

FIG. 11.—A tomato plant pruned to a single stem tied to a stake.

Pruning tomatoes, as commonly practiced, consists of cutting or pinching out all side branches as they appear about the base of the plant or in the axils of the leaves. Careful observation will show that the side shoots appear in the axil, or pocket formed by the leaf where it is attached to the main stem, while the fruit clusters are on the opposite side from the leaf and often a little above or below the point where the leaf is attached, as shown in Figure 14. The side shoots should be removed at least once a week during the active growing period, in order to throw all the vigor of the plant into the formation of fruit. In Texas and Mississippi the heart of the plant is pinched out after four or five good clusters of fruit have been formed. This practice of pinching out the heart of the plants is also followed in some of the North-Central States where it is desired to market only the early crop.

Growers of early tomatoes around Buffalo, N. Y., New Haven, Conn., and elsewhere in the Northeastern States follow a practice known as "leaf pruning" to stimulate the early formation of the branches and the setting of a large number of fruit clusters. This is contrary to the single-stem method and consists of pruning away all the leaf except the inner two lobes or segments while the plants are from 6 to 8 inches in height. After the branches have started no further leaf pruning is practiced, and the plants are allowed to grow upon the ground in the usual manner. This system, it is claimed, causes the tomatoes to ripen 5 to 10 days earlier and at the same time gives a heavy yield of early fruit. In view of the fact that no definite experiments have been reported it is impossible to state the advantage, if any, to be gained by this method, though it is practiced by a considerable number of growers of early tomatoes.

INSECTS AND DISEASES.

The tomato is subject to the attacks of a number of insects and diseases which require prompt attention on the part of the grower. The insects that are most destructive are cutworms, tomato hornworms, the tomato fruitworm, and flea-beetles. The diseases that are most injurious are leaf-spot, early and late blight, mosaic, blossom-end rot, and Fusarium wilt. The following brief suggestions[3] are intended to serve as first aid to the grower, but where there is any considerable insect or disease infestation more detailed information should be obtained either from the agricultural college and experiment station of the State in which the grower resides or from the Bureau of Plant Industry or the Bureau of Entomology of the United States Department of Agriculture, depending upon whether the trouble is caused by diseases or insects. A number of Federal and State bulletins which include information upon insects and diseases of the tomato are available, and the grower is advised to procure these in advance and fully inform himself as to what insect and disease troubles he is liable to encounter.

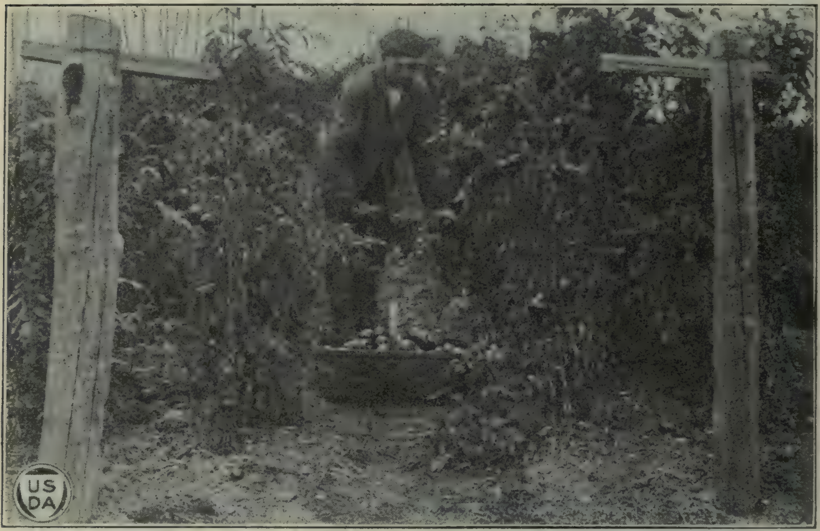

FIG. 12.—Tomatoes trained to light bamboo stakes which are supported by wires at the top.

Several forms of cutworms attack young tomato plants both in the plant bed and when they are set in the field, usually cutting them off at the surface of the ground. The best control measure is by the use of what is termed "poisoned bait." This is made in the following manner: To 1 peck of dry bran add 4 ounces of white arsenate,

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[3] For more detailed information see Department Circular 40, Insect Enemies and Diseases of the Tomato.

Paris green, or other arsenical. Add 2 quarts of cheap molasses and enough water to make a wet mash. After the mash has stood for several hours scatter it very thinly about the base of the plants late in the evening. Apply a second or third time if necessary.

Tomato hornworms are large green worms 2 to 4 inches in length, shown in Figure 15, sometimes called tomato worms or tobacco worms, which feed equally well on both tomato and tobacco plants. They are the larvæ or young of large moths, known as sphinx moths, of two species, very similar in habits and distribution. These insects produce two broods, and the worms eat the leaves from the tomato plants. Hand picking is recommended, but hornworms are so near the color of the foliage that they are difficult to locate even on the plants from which the leaves have been partially stripped. Where the worms are especially abundant the plants should be sprayed with arsenate of lead at the rate of 2 pounds of the dry or 4 pounds of the paste form of the arsenical to 50 gallons of water, or the arsenate may be added to Bordeaux mixture used to control tomato blight.

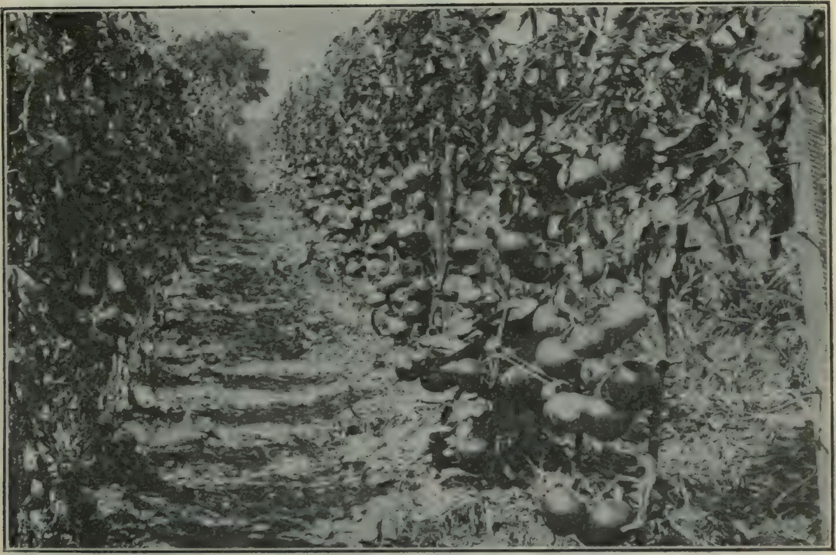

Fig. 13.—Tomato plants trained on wire trellises.

The tomato fruitworm is the same insect as the bollworm (not the boll weevil) of cotton and the corn earworm. (Fig. 16.) This insect causes heavy losses of early tomatoes by its eating into the fruits and destroying their market value, as shown in Figure 17. Spraying the tomato fruits three or four times with lead arsenate, in the same proportions as given for hornworms, will almost completely control the tomato fruitworm. The first spraying should be done when the earliest tomato fruits are about an inch in diameter and repeated at intervals of a week or 10 days until the fruits are almost full grown. The spraying for the fruitworm can also be combined with applications of Bordeaux mixture.

Flea-beetles often cause great damage to the plants in the hotbed and coldframe or when they are first set in the field. The presence of flea-beetles on the young tomato plants will be made known by the appearance of the leaves, the injured ones being lighter in color and pitted with small holes. Spraying the young plants with 1½ pounds of the dry form of lead arsenate in 50 gallons of water affords considerable protection. Bordeaux mixture acts as a deterrent, and it is a good plan to combine the arsenate with it. Dusting the plants lightly with dry air-slaked lime or with nicotine sulphate dust is effective in controlling flea-beetles.

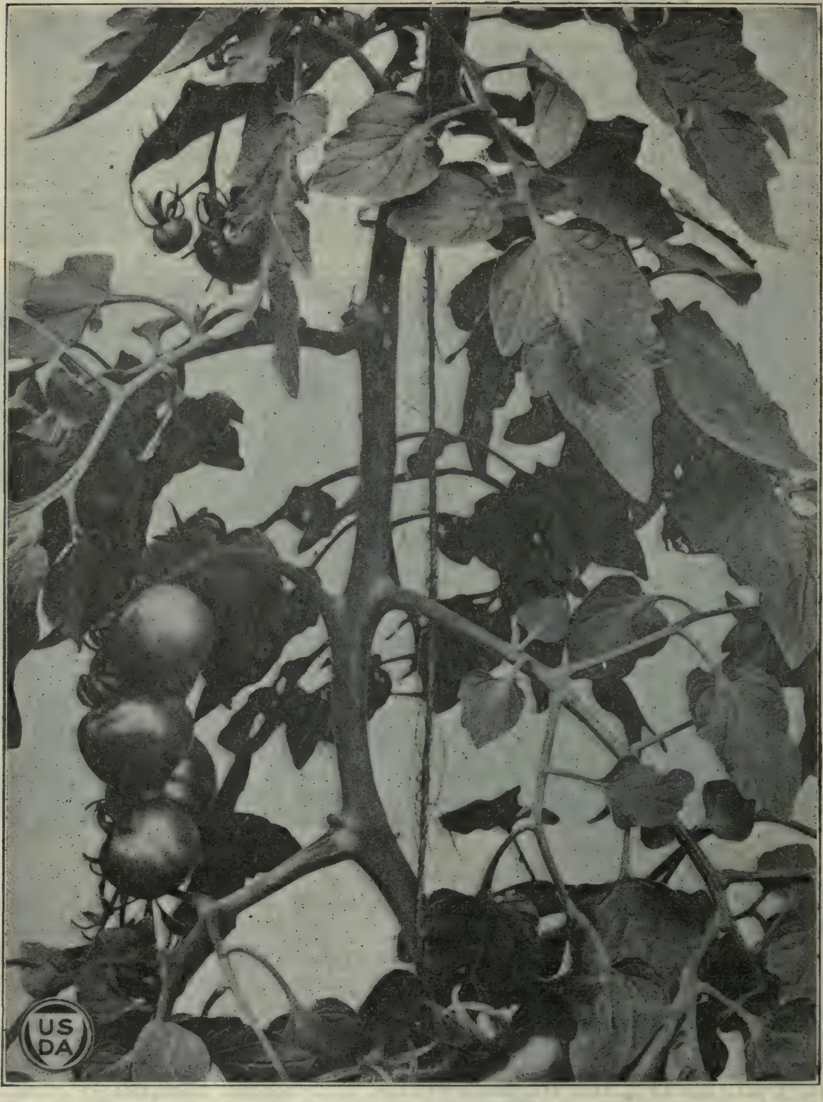

FIG. 14.—Section of a pruned tomato plant, showing the location of leaves and fruit clusters on the main stem.

Leaf-spot is a disease in which the leaves, beginning at the base of the plants, become covered with dark-brown spots and then shrivel and die. Spraying with Bordeaux mixture and resin-fishoil soap before the disease gains headway, repeating the spraying every 10 days, is effective. In spraying it is important to cover the lower side of the leaves as well as the upper side. The 4–4–50 formula for Bordeaux mixture is most commonly employed, with 3 to 4 pounds of resin-fishoil soap added to each 50 gallons. Dissolve 4 pounds of bluestone in 25 gallons of water and slake 4 pounds of lime in a small quantity of water and dilute to 25 gallons. Pour the two solutions together and add the resin-fishoil soap, which has previously been dissolved by adding a few drops of hot water at a time, stirring well until the sticky soap is dissolved. The soap causes the Bordeaux mixture to spread and to stick better to the shiny smooth surface of the leaves.

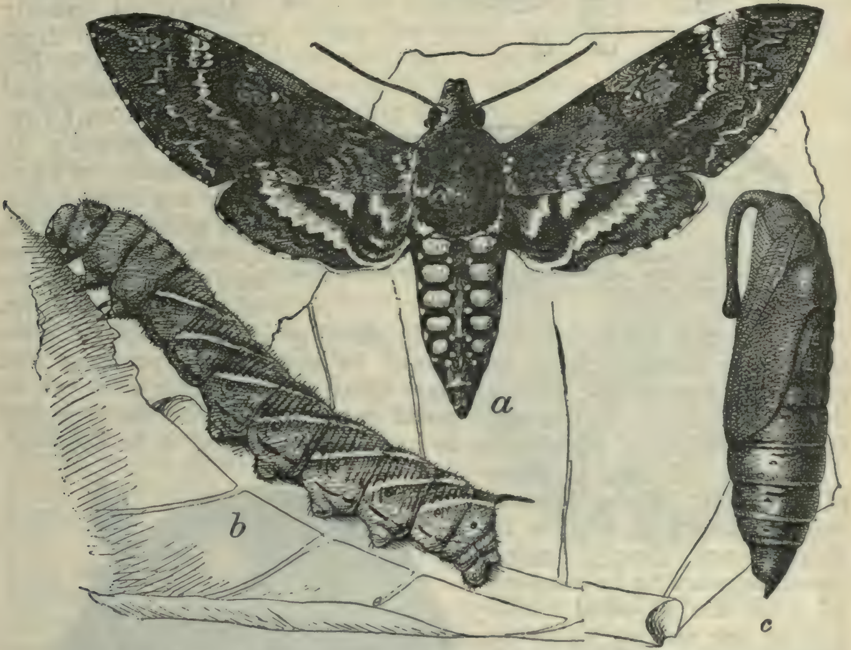

Fig. 15.—One of the tomato hornworms (*Phlegethontius sexta*) : *a*, Adult moth ; *b*, larva ; *c*, pupa. (Howard.)

Early-blight, which causes a rapid blighting of the leaves and decay of the fruit, is due to a fungus. There are two forms of this blight. One causes a spotted discoloration of the fruit known as nail head and is only skin-deep. This disease is especially prevalent in the South. The other form causes a black decay which extends to the center of the fruit. This form of the disease is especially troublesome in the North. Spraying with Bordeaux mixture is the control measure usually recommended.

Late-blight, which also causes a blighting of the leaves accompanied by rotting of the fruit, is due to the same fungus that causes potato late-blight. Spraying with Bordeaux mixture is also a preventive for this disease.

Mosaic produces on the leaves mottled areas of different shades of green and sometimes crinkles and distorts the leaves, causing the plants to be weak and unfruitful. There are various types of this disease. The fern-leaf type, in which the leaves become very narrow, and the shoe-string type, in which the leaves develop only as long strings, are the most important.

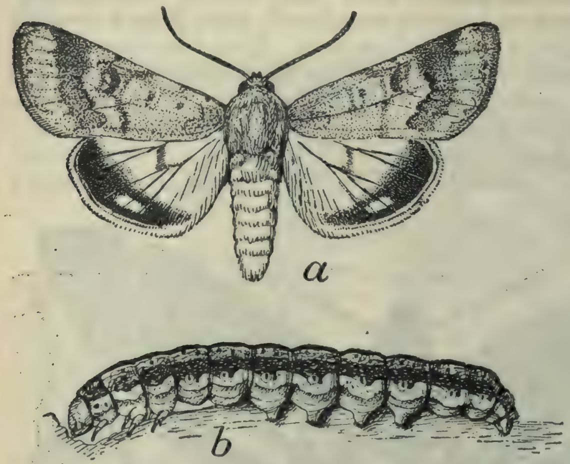

FIG. 16.—The tomato fruitworm, bollworm, or corn earworm (*Chloridea obsoleta*): *a*, Moth, or adult; *b*, larva. About natural size. (Howard.)

Mosaic is readily transmitted from plant to plant by lice and other insects and also by contact. Plants grown in greenhouses, where there are older tomatoes affected with the disease, while not showing any trace of the mosaic when moved to the field, will invariably develop it later. The disease is readily carried from one plant to another in pruning and tying. When mosaic once appears there is very little that can be done to eradicate it, the main point being to exercise extreme care in the growing of plants and to avoid transferring it to the field.

Blossom-end rot, a decay of the fruit at the blossom end, as shown in Figure 18, though not clearly understood, appears to be connected with the physical condition of the soil on which the crop is grown. While many growers believe that this disease has its greatest development during periods of deficient moisture supply, experiments have failed to show that irrigation will control it. Mulching the ground around the tomato plants is thought by many growers to be a preventive, but the effectiveness of this treatment has not been adequately proved in experiments.

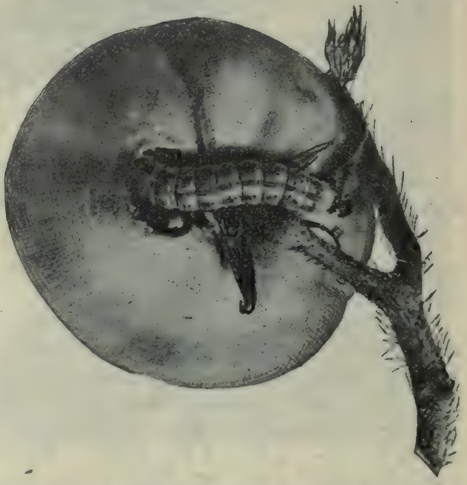

FIG. 17.—Tomato fruitworm, showing its characteristic work. (Quaintance and Brues.)

The wilts of tomatoes are especially prevalent in the South, where about three forms of the disease are found. Fusarium wilt causes the plants to wilt and die slowly, while bacterial wilt causes the plants to die suddenly. The planting of wilt-resistant strains or varieties applies especially to the control of the Fusarium wilt. The important considerations in the growing of tomatoes in sections where wilts prevail are to plant the tomatoes only on land (1) that is free from these diseases and (2) that has not grown weeds closely related to tomatoes. Care must be taken also that the soil of the plant bed is clean and free from wilt. The variety of tomato known as Norton is perhaps the best adapted for growing in sections where Fusarium wilt is widespread.

GATHERING AND PREPARING THE CROP FOR MARKET.

Early tomatoes grown in the Southern States and those imported into the United States during the winter months are gathered before they are fully ripened, on account of the shipping distance and the time required for them to reach the markets. Two stages of maturity are recognized, depending upon the length of haul and method of shipment: "Green" stock, the individual tomatoes of which are gathered before they show any pink color, wrapped in thin paper, and shipped in ventilator cars; "pink" stock, which shows varying degrees of color, is seldom wrapped, and is shipped under refrigeration where the time required to reach the market is more than 24 hours. The tendency in the Southern States during recent years is more and more toward the production of green stock for distant marketing. The green wrapped tomatoes usually carry better, and refrigeration costs in most cases are saved. Where the haul exceeds 8 or 10 days the green wrapped stock is shipped in refrigerator cars without ice but under ventilation during transit for the first five or six days, and then iced to destination.

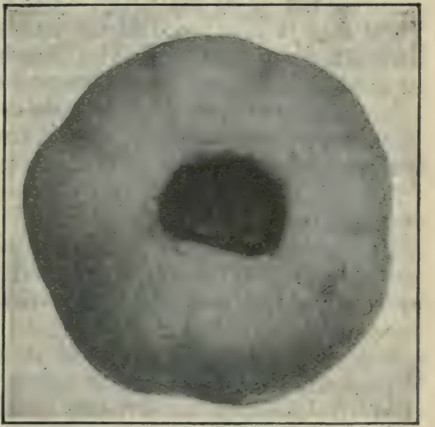

FIG. 18.—Tomato blossom-end rot.

Tomatoes that are picked and shipped in the green state do not have the same flavor and quality as those that either become pink or completely ripened upon the vine. For this reason, it is essential in gathering the green stock that they reach as complete a stage of maturity as possible. In the past the pickers of green tomatoes, especially those in the southern Florida districts, have not given proper attention to the maturity of the fruits, the size being the main determining factor, and as a result these tomatoes have gone through a ripening process either before shipment or after reaching their destination. The future of the green-tomato industry depends to a considerable degree upon remedying the present careless methods of gathering the fruit.

No definite rules have been established for determining the maturity of the fruits gathered for green shipment. The most common and practical test is to cut a few average tomatoes crosswise of the seed cells with a sharp knife, and if the pulp that surrounds the seeds has become slightly jellylike, so that the seeds give way before the edge of the knife and are not cut in slicing, they are ready for shipment as green stock. The persons doing the picking soon learn to recognize the proper stage of maturity by color and general appearance. The size of the tomato fruits is no guide to the maturity, as it is the age of the tomato that determines its development. Color and general appearance vary to some extent with different varieties; here again the experience of the pickers must be relied upon. Toward the end of the picking season green tomatoes have a greater tendency toward internal coloring than they have earlier, and for this reason they should be handled more promptly. This is undoubtedly due to extremely hot weather and the exhausted condition of the vines. The tomatoes also as a rule will run smaller toward the end of the picking season.

When it comes to gathering pink stock; color is the main determining factor of maturity. Uniformity of color is extremely important, and it is often difficult to obtain a pack of pink stock that will run uniform. During the height of the shipping season picking should be frequent, every second day or every day, in order to have the fruits uniform and to avoid overripeness. Green stock can be picked twice the first week and three or four times a week thereafter. In many sections the picking is practically a continuous process, the vines being gone over as often as possible and no fruits allowed to become too far advanced.

It should be understood that pink stock shipped 700 or 800 miles under refrigeration as a rule will be ripe enough for use by the time it reaches the consumer, but that the green stock either ripens in transit without icing or is placed in a ripening room when it reaches its destination. In any case it is essential that the green stock be repacked, the riper fruits being placed in packages by themselves and the greener ones held until properly colored. Many of the wholesale dealers in tomatoes maintain repacking and ripening rooms during the shipping season. As the cars are received the tomatoes are sorted, and those requiring further ripening are placed in a room at a temperature ranging from 70° to 75° F., with suitable moisture conditions and held three to six days or sometimes longer, until they are ripe enough to be placed on sale. The usual method of maintaining proper moisture conditions in the ripening rooms is to place a few shallow pans of water on the floor in different parts of the room and by the use of small sprinkling cans to spray a little water over the paper wrappers of the green tomatoes that have been repacked. By maintaining proper moisture conditions there is very little loss from shrinkage in the weight of the tomatoes, and the fruits do not have a shriveled appearance when they become fully ripe.

Formerly, early green tomatoes were practically all packed on the farms where grown, but this system has now been largely replaced by packing in centralized sheds. Where the tomatoes are packed on the farm a temporary shelter or shed is usually constructed at one end or side of the tomato field. Sometimes a wagon shed or similar shelter near the dwelling is used. By the centralized packing method the grower is relieved of everything pertaining to packages and packing and simply delivers his product to the packing shed and receives a duplicate slip covering the weight or number of packages delivered, while the entire work of grading and packing is done by the packing-shed force.

Galvanized-iron buckets, half-bushel round-bottom stave baskets similar to those used for picking orchard fruits, 12-quart climax baskets, and 16 and 20 quart round hamper baskets are used for picking in the field. Of these the half-bushel round-bottom orchard baskets with broad collapsible wood handles are perhaps the most desirable. Where the tomatoes are transferred in the field from the picking utensils to lug boxes, bushel crates, or bushel baskets for hauling to the packing shed, great care must be taken in pouring them from one container to another, to avoid bruising. The interior of all picking utensils should be carefully inspected to see that there are no sharp edges, nail points, or rough surfaces to injure the fruit. Many growers follow the practice of lining their picking baskets with heavy muslin, light canvas, or burlap. Small breaks in the skin which may not be noticed when the tomatoes are packed often cause serious loss in transit and on the market. Field crates or lug boxes used for hauling the tomatoes from the field to the packing shed should be light in weight, but strong and durable. They should be provided with cleats across the top at each end to prevent bruising the fruit either in the wagon or in stacking at the packing shed. The lug box used for handling oranges from the grove to the packing shed in Florida is a desirable type, but it has the objection that it is too large for one man to handle. A good type of bushel box is, from many standpoints, better. Tomatoes should never be hauled in bulk, even though the wagon bed is well padded, as the weight of the fruit in a load 20 to 26 inches deep causes serious bruising and internal injury of the fruit.

Pink stock in the past has been packed more largely on the farms where grown than green stock, but recent developments have been along the line of centralized packing and handling. The methods used are practically the same as those for green stock, except that the pink stock is not wrapped in paper and must be handled with the least possible delay.

Early tomatoes grown in the Southern States are packed largely in such 6-basket carriers and 4-basket flat crates as are shown in Figures 19 and 20. The grades, packs, and type of package used for handling southern early tomatoes, which are shipped mainly to the northern markets, are fully described in Farmers' Bulletin 1291, entitled "Preparation of Fresh Tomatoes for Market," and the consideration of these subjects is therefore omitted from this publication. The methods of handling tomatoes grown for local sale in the Southern States as well as those of the producing sections in the Northern and Eastern States are, however, so different from those of the shipping sections of the South as to require description in this bulletin.

The degree of ripeness of tomatoes grown for the early and general markets in the regions outside of the intensive early sections of the South depends upon the locality and the method of delivery to the markets. Those grown in Tennessee, southern Ohio, and other sections of similar latitude and conditions are gathered in the advanced pink stage or when this color covers two-thirds or three-fourths of the tomato. In this condition the tomatoes will be ready for use by the second or third day after gathering and in many cases will keep from five to seven days in good condition. In sections where the tomatoes are hauled direct to the market and offered for sale within 24 hours of the time they are gathered, the fruits are allowed to become almost fully ripe upon the vines. Tomatoes that are grown for household canning as a rule are left on the vines to become uniformly red ripe but not soft or overripe. During the early part of the season while prices are high the plants are gone over every day or every second day, but during the height of the season the tomatoes are usually gathered about twice or three times a week.

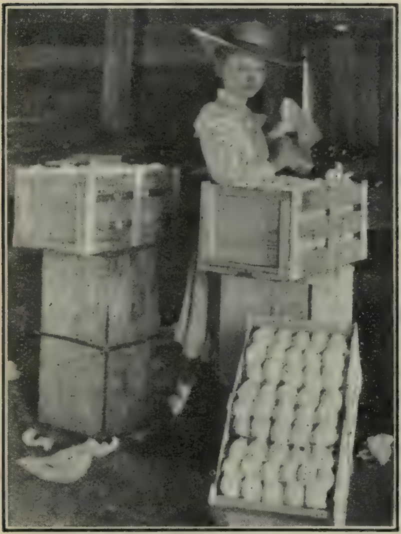

FIG. 19.—Green tomatoes wrapped in special paper and packed in 6-basket carriers.

The methods of packing tomatoes for local markets vary in different localities. Most of those grown for the early market, however, are gathered in field baskets and either hauled or carried to a central packing shed, where they are cleaned by means of soft cloths and then packed in baskets, crates, or whatever package is best suited to the market. Peck and half-bushel splint baskets with handles and 12-quart climax baskets are often used, especially during the earlier part of the season. In some sections the half-bushel round hamper is a favorite package. The New Jersey 20-quart crate is widely used in the Swedesboro and southern New Jersey sections for car-lot shipments of fresh tomatoes. A larger size, holding from 27 quarts to 1 bushel, is popular in northern New Jersey, adjacent to New York. These crates are usually made from unfinished material, presenting a rather unattractive appearance in the markets. They have the disadvantage that the weight of the fruit in the package frequently causes crushing of the bottom layers. They have the advantage, however, of being strongly made and seem to give satisfaction in the movement of low-priced stock to neighboring markets. The 20-quart brace hamper or round basket used in the Philadelphia and Baltimore districts for rail and boat shipments to canneries is very extensively used for marketing tomatoes. In most cases these baskets are nested together and returned to the growers. In the shipping sections of Ohio, Indiana, Illinois, and Missouri the 12-quart climax basket is used to some extent, but has the disadvantage that the handles are easily broken and that it is rather deep, and a single overripe fruit in the basket is liable to injure its entire contents. In the New England States the standard bushel or "Boston box" shown in Figure 21 is most generally used. The inside dimensions of this box are 17½ by 17½ by 7 1/16 inches. When carefully packed with firm, smooth, uniform-sized tomatoes, this box holds 60 to 63 pounds.

The important consideration in the selection of a package for the local marketing of tomatoes is to secure one that is strong, of neat appearance, and that can be conveniently handled. Where the tomatoes are sold in the original package to families, the 4-quart flat basket, the 1-peck splint basket, the 12-quart climax basket, and the half-bushel round hamper are desirable packages. Tomatoes that are to be used for canning in the home are most conveniently delivered in half-bushel or five-eighths bushel round baskets or in standard bushel boxes or crates.

One important factor in the handling of tomatoes is that the containers and the wagon, truck, or other vehicle on which they are transported shall be adapted to each other. In many cases special racks or frames are built upon the wagons to carry the baskets or hampers. Standard bushel boxes are almost universally constructed so that they will pile one upon the other.

In the southern New Jersey early-tomato section the leading markets of the eastern United States are within truck-hauling distance, and a large part of the crop is delivered by motor truck. While the district around Swedesboro still holds a record for very heavy car-lot shipments, the building of hard-surfaced roads to Philadelphia and other eastern cities has made possible the hauling of 80 to 100 bushels at a truck load, and large quantities are moved in that manner. Tomato-growing sections that are located on the rivers and salt-water inlets ship by boat to a considerable extent. Water transportation, however, as a rule, is too slow for the handling of early or truck-crop tomatoes, and boats are used primarily for the transportation of those intended for canneries.

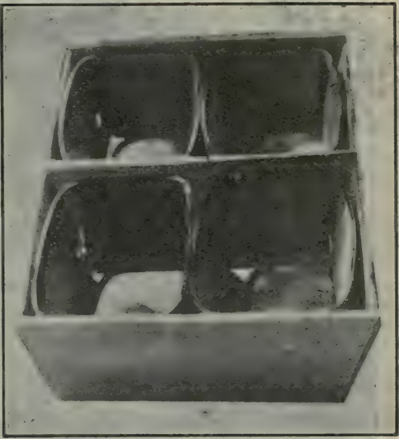

FIG. 20.—A 4-basket carrier used in some sections for shipping early tomatoes.

Adherence to the standard grades, as described in Farmers' Bulletin 1291, is of great importance from the standpoint of increasing the demand for table tomatoes. The southern grower can gain nothing by sending hundreds of miles to market culls that must be either discarded when re-sorted or sold at a price that will not pay transportation and handling costs. The term "culls" as used here includes all undersized and immature fruits, as well as those that are rough, cat-faced, and irregular; also those that are cracked and leaky and in such condition that decay sets in during transit. The centralized packing shed with expert graders and packers has gone a long way toward educating the growers (1) in the production of a high-grade product and (2) in the matter of proper gathering to leave the culls in the field and to bring only marketable stock to the packing shed. Cases are known where individual growers have had less than 10 pounds of " rejects " from a whole day's picking of 3 to 5 acres of staked and pruned tomatoes.

In the northern sections, where the fruits are packed largely in the field or in packing houses located on the farms, it is extremely difficult to establish grades, and the result of this lack of uniformity and standards is reflected in the prices obtained. Cases have come under observation where high-grade tomatoes of superior quality, well packed in standard bushel boxes, were selling for $4.50 a box on the grower's premises, while miscellaneous, field-run tomatoes of another section which were dirty, lacking in uniformity of ripeness, and poorly graded were a drug on the same market at $1.50 per bushel.

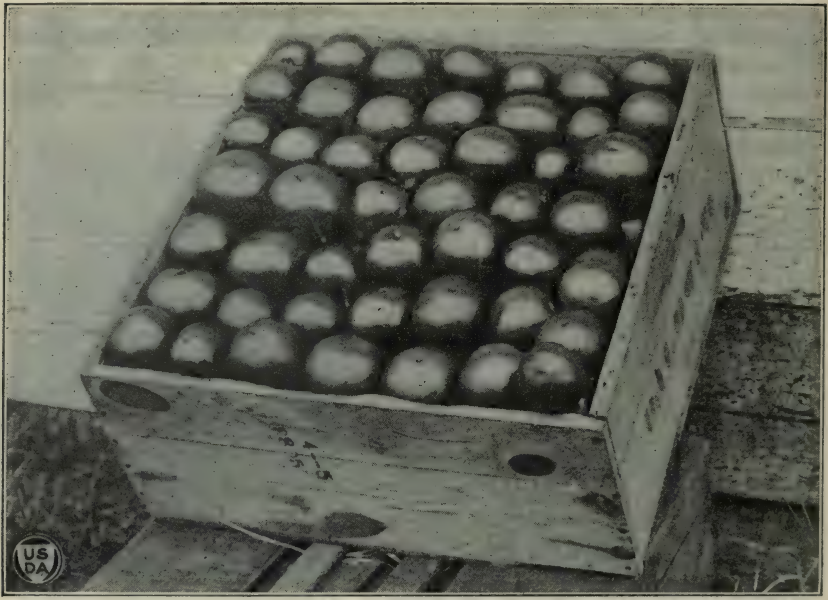

FIG. 21.—Tomatoes packed in a standard bushel box known as the " Boston box."

The grower of the high-grade tomatoes was making a handsome profit, while those who were producing the low-grade stock were complaining that there was nothing in the growing of tomatoes.

SUMMARY.

Profitable early-tomato production depends to a considerable degree upon the selection of soil of the proper character in a well-protected location, with good drainage and abundant drought-resisting properties.

Good seed of a variety and strain adapted to the purpose for which the crop is being grown is very important, and while seed of this character should cost very little more than ordinary seed the matter of price paid for the seed should be of secondary consideration.

The proper growing of the plants by means of hotbeds, coldframes, blocking off, and in some cases by the use of pots is essential to the production of a satisfactory early crop of tomatoes.

The intelligent use of manure and fertilizer and the thorough preparation of the soil are essential steps in profitable tomato growing. Frequent shallow cultivation and the spraying of the plants to protect them from insect and disease injury is essential.

Tomato plants should not be set in the open ground until all danger of frost is past, and earliness as well as yield depends to a considerable degree upon the care used in transferring the plants from the plant bed to the field.

Staking and pruning the plants is a distinct aid in the production of an early crop, but may not be practicable on a large scale. The proper maturity of the fruit, depending upon the distance from market and the method of handling, is highly important, and a knowledge as to when the fruit should be gathered must be gained largely by experience. It is the age rather than the size of the fruit that determines its stage of maturity.

The production of high-grade uniform fruit is essential, but the proper grading, packing, and marketing of the crop largely determine the profits.

Early and truck-crop tomatoes are now grown on a very large scale, approximately 120,000 acres of land being devoted to this phase of the tomato industry in the United States.

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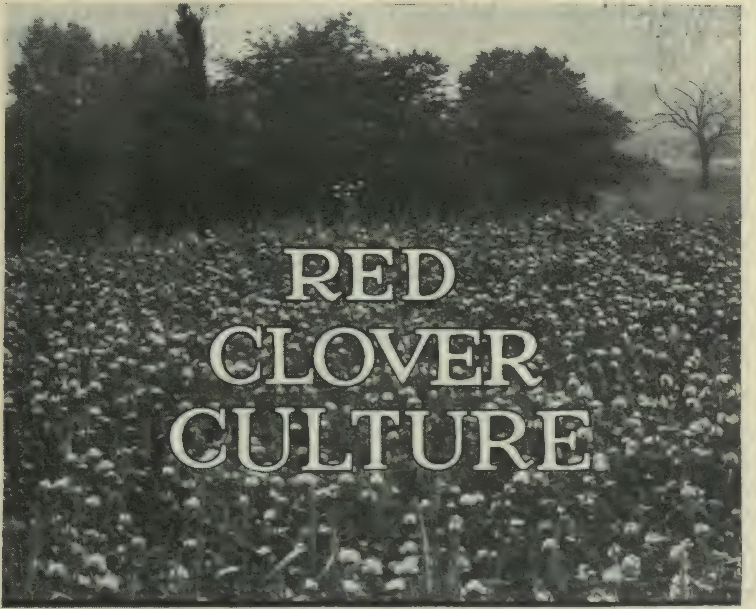
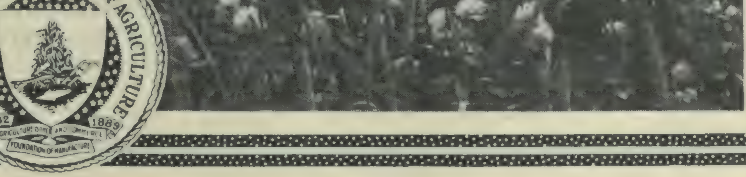
FARMERS' BULLETIN No. 1339



RED CLOVER CULTURE



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RED CLOVER is the most important leguminous forage and soil-improving crop in the north-eastern quarter of the United States.

It will grow on any well-drained fairly rich soil that has plenty of lime in it. Without lime or on hard run-down land in which the organic matter has been exhausted by bad cropping, it will not thrive.

The most common method of seeding is on winter grain, but it also is often seeded with spring grain. Late summer seeding is successful in much of the southern and eastern part of the clover area.

Red clover is most often seeded with timothy, though sometimes with other grasses. With timothy the hay of the first crop year is mostly clover; the second year the timothy is most heavy, and after that the clover largely disappears.

Clover is most used in rotations with a cultivated crop and a small-grain crop in three, four, and five year rotations.

Root borers and other insects as well as fungous diseases make it undesirable to keep a field of pure clover more than one crop year.

The use of high-quality seed of American production is strongly advised. Imported seed is often unfit for use in the United States, and seeding it is always risky.

The secret of haymaking consists in the rapid removal of the moisture from the cut plants without killing the leaves prematurely.

Seed is usually taken from the second crop. The yield is always more or less uncertain, and over much of the clover area it is cut down more by the clover-flower midge and the clover-seed chalcis fly than by any other factor. The injury caused by these insects can be minimized by cutting the first crop a little earlier than is usually done.

RED-CLOVER CULTURE.[1]

By A. J. PIETERS, *Agronomist in Charge of Clover Investigations, Office of Forage-Crop Investigations, Bureau of Plant Industry.*

With Notes on the Insect Enemies of Red Clover, by W. R. WALTON, formerly *Charge of Cereal and Forage Insect Investigations, Bureau of Entomology.*

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INTRODUCTION.

RED CLOVER[2] is one of the most important and most widely known of all cultivated legumes. Either alone or in mixture with other plants, chiefly timothy, it is the most used forage and soil-improving crop throughout northern and central North America and Europe, and its culture as a rotation crop extends far beyond these boundaries. For centuries it has been regarded as the corner stone of a permanent system of agriculture in the Old World, while in this country for nearly 200 years it has been a leading factor in conserving productivity of the soil. The distinguished part which red clover has played in maintaining a profitable world agriculture can scarcely be overstated.

Red clover is adapted primarily to growing in rotations with other crops, and it has therefore been largely used in those regions where a variety of crops is grown. By far the most common method of utilization is to grow it in a three or four year rotation, including a cultivated crop and a small-grain crop, the first crop of clover being cut for hay and the aftermath being turned under or allowed to go to seed. This is an exceedingly economical and convenient procedure, and, together with the high feeding and fertilizing value of the plant, largely accounts for its dominant position among farm crops.

The most serious problem at present confronting the American farmer in many of the clover sections is the increasing difficulty of successfully maintaining stands of clover.

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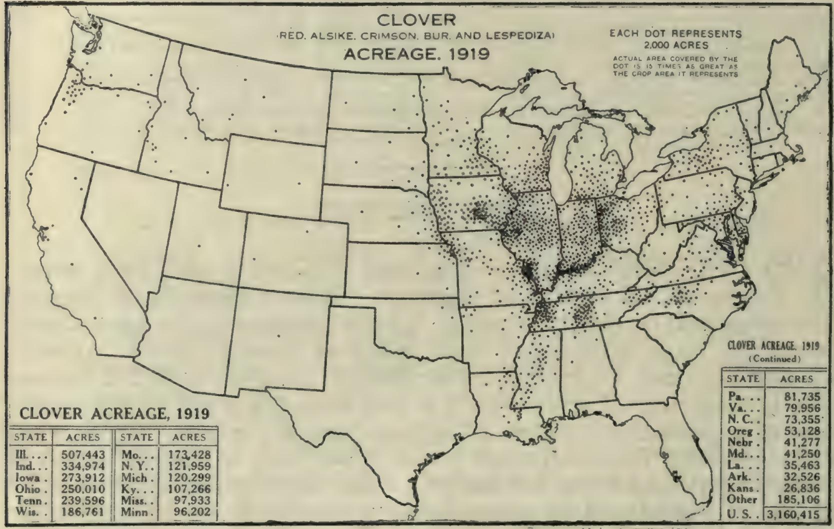
[1] This bulletin is a revisioon of and supersedes Farmers' Bulletin 455, "Red Clover, by J. M. Westgate and F. H. Hillman.

[2] When the term "red clover" is used in this bulletin, the common red, medium red, or June red clover (*Trifolium pratense*) is to be understood. For other varieties, see p. 23.

With continuous cropping and the consequent reduction of the humus and plant food in the soil the difficulty of growing red clover is greatly increased. This condition must be met and solved, since the loss of clover or its equivalent from the rotation leads rapidly to a run-down farm and unprofitable crop yields.

HISTORY AND PRESENT DISTRIBUTION OF RED CLOVER.

Red clover is native to the greater part of Europe and portions of Asia. The exact date of its introduction into America is not known, but in a work on agricultural plants written in 1747 by Jared Eliot observations concerning its adaptability to conditions in the New England States are noted. Since its introduction into this country it has spread greatly and is now grown to a considerable extent in nearly all the sections of the United States where there is sufficient rainfall. In the irrigated sections of the arid portions of the West red clover is largely replaced by alfalfa, but even in the irrigated sections in mountain valleys red clover is an important forage crop.


CLOVER
(RED. ALSIKE. CRIMSON. BUR. AND LESPEDIZA)
ACREAGE. 1919
EACH DOT REPRESENTS 2,000 ACRES
ACTUAL AREA COVERED BY THE DOT IS 15 TIMES AS GREAT AS THE CROP AREA IT REPRESENTS

CLOVER ACREAGE, 1919

STATE	ACRES	STATE	ACRES
Ill....	507,443	Mo...	173,428
Ind...	334,974	N. Y..	121,959
Iowa .	273,912	Mich .	120,299
Ohio .	250,010	Ky...	107,266
Tenn .	239,596	Miss. .	97,933
Wis. .	186,761	Minn .	96,202

CLOVER ACREAGE, 1919
(Continued)

STATE	ACRES
Pa. . .	81,735
Va. . .	79,956
N. C. .	73,355
Oreg .	53,128
Nebr .	41,277
Md. . .	41,250
La. . .	35,463
Ark. .	32,526
Kans .	26,836
Other	185,106
U. S. .	3,160,415

FIG. 1.—Outline map showing the acreage of clover grown alone (for timothy and clover mixed, see fig. 10). "Clover" may mean red, mammoth, or alsike clover in the Northern and Central States; crimson clover, a very different plant, in the Coastal Plain of Delaware, Maryland, and Virginia; bur clover in parts of the South; and it was specifically stated in the census schedule to include lespedeza.

The accompanying map (fig. 1) shows the distribution of all clovers in the United States according to the census of 1920. Each dot represents 2,000 acres in the region where the dot is located.

DESCRIPTION OF THE RED-CLOVER PLANT.

The accompanying illustrations (figs. 2 and 3) indicate the general appearance of the red-clover plant. The plant is herbaceous and is composed of numerous leafy stems arising from a thick crown.

Red clover usually lives only two years and for this reason is especially adapted to short rotations. The flowers are borne in compact clusters or heads at the tips of the branches. There may be a hundred or more flowers to a single head. The flowers are rose-pink, somewhat similar in shape to pea flowers but much more elongated and smaller, being half an inch in length and one-sixteenth of an inch in width. The pods bear little resemblance to those of most other legume-bearing plants; they are small, short, and break open transversely instead of longitudinally as do pea and bean pods. (Fig. 4.) The kidney-shaped seeds are one-twelfth of an inch long and vary in color from yellow to deep violet. The stems comprise about three-fifths of the total weight of the plant above ground and in the American strain are usually somewhat hairy. Each leaf is composed of a slender stalk bearing three oblong leaflets, usually with a pale spot in the center of each. The roots are much branched, but usually deep feeding and are ordinarily well supplied with nitrogen-gathering tubercles. (See fig. 3.)

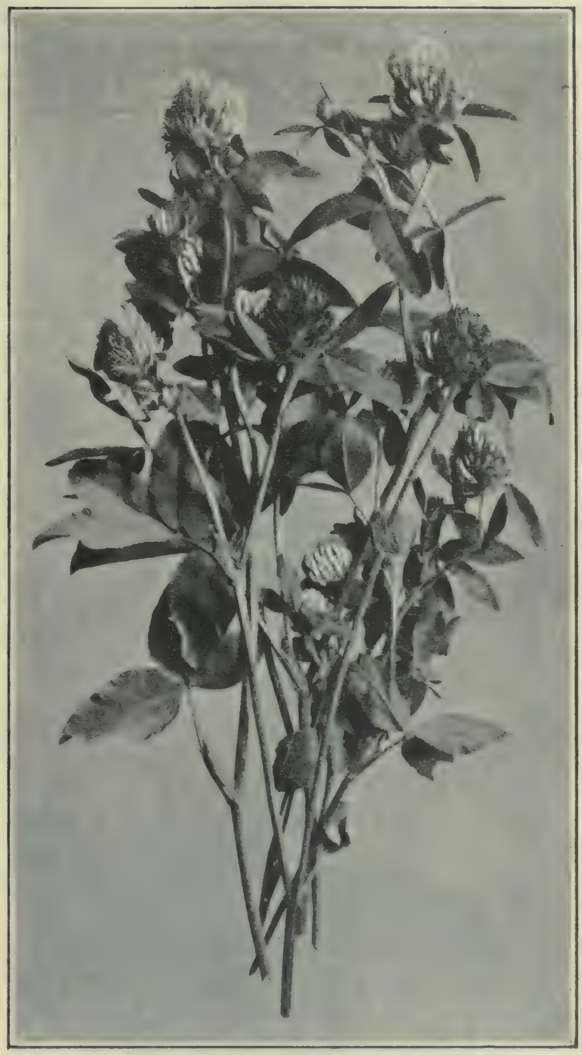


Fig. 2.—Stems of red clover in different stages of bloom.

WHERE RED CLOVER THRIVES.

Besides being the staple leguminous forage crop in the northeastern quarter of the United States, red clover is also grown in Idaho, Washington, Oregon, and in many of the valleys of the Mountain States. In the South it is locally grown, usually as a winter crop, though there are places with rich moist soil where it does well the year around. In North Dakota red clover is being replaced by sweet clover, while in irrigated sections of the West alfalfa is preferred except in some mountain valleys where the growing season is too short for three crops of alfalfa, and especially where a leguminous crop is desired in connection with the customary grain crop. In some irrigated sections where the conditions are especially favorable for seed production it is grown primarily for seed.

Red clover makes its best growth on rich, well-drained soil containing an abundant quantity of lime and reasonably free from weeds, but it is not so exacting as alfalfa in these respects. To low, poorly drained soils it is not so well adapted as alsike clover. Alsike will also succeed on the so-called clover-sick lands upon which for one reason or another red clover can no longer be successfully grown by the ordinary methods.

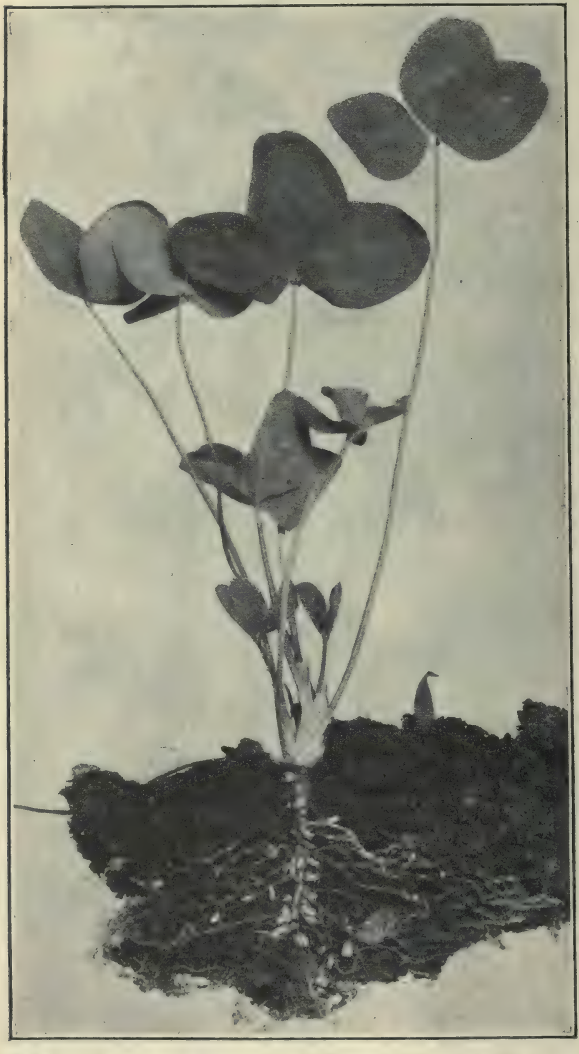


FIG. 3.—Young red-clover plant, showing tubercles on roots.

REQUIREMENTS FOR OBTAINING A STAND OF RED CLOVER.

CHOICE OF SEED.

The effort for a profitable stand of red clover has been well begun when the seed has been carefully selected. Three points must be considered in selecting clover seed: Purity, germination, and source of seed.

PURITY.

Good red-clover seed is plump, bright, and varies in color from yellow to deep violet. Some brown seeds are nearly always present, but in a good sample they should not be numerous, since brown seeds are often dead. The impurities consist of dirt, sticks, broken seed, and seeds of other crop plants or of weeds. In all but the last case the farmer merely pays clover-seed prices for useless stuff, but when weed seeds are present he not only pays for them in the first place, but he may be put to considerable additional expense for a term of years. This is especially true if the weed seeds are those of buckhorn, wild carrot, Canada thistle, or dock. If a farmer uses his own seed or buys from a neighbor, he should reclean the seed as carefully as possible before seeding; if he buys from a dealer he should first have the seed examined by his State seed-testing laboratory if there is any doubt as to its quality. A simple magnifier, American made, such as is shown in Figure 5, is a useful thing and can be bought for about 75 cents. With it anyone can readily pick out the weed seeds in a sample of clover. Some of these weed seeds are shown in Figure 6. Good red-clover seed should be at least 95 to 98 per cent pure and should contain few weed seeds. Owing to the Federal seed-importation law and the various State laws, the deliberate adulteration of clover seed is now relatively rare.

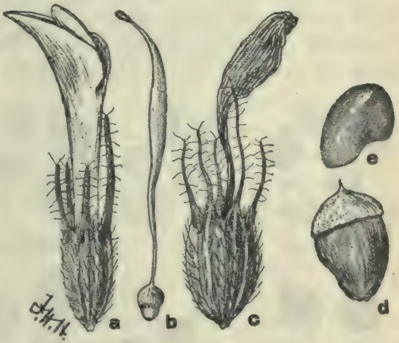


Fig. 4.—Stages in the development of red-clover seed: *a* and *c*, Flower in prime and ripe; *b* and *d*, immature and mature seed vessel; *e*, mature seed.

GERMINATION.

A bright fresh-looking lot of red-clover seed will usually germinate pretty well, but it is so easy to test the germination in advance that there is little excuse for sowing poor seed. If 100 or 200 average seeds are counted out and laid on a plate between pieces of moist cloth or blotting paper, as shown in Figure 7, and the plate set away in a room where the temperature is 65° to 80° F., the seeds will begin to sprout in three or four days, and in a week the value of the seed so far as germination is concerned can be definitely determined. The germination of clover seed, even when the sample is good, will depend somewhat on the number of hard seeds present. A sample of good seed should test something like 90 per cent, with at least several of the remaining seeds hard at the close of the 10-day test period. It is thought that one-third of the hard seeds will grow promptly when seeded.

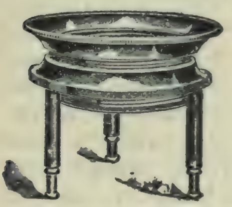


Fig. 5.—Simple magnifier for examining seeds.

SOURCE OF SEED.

During the past 15 years considerable quantities of red-clover seed have been brought to the United States from foreign countries. Some of this seed was grown in southern Europe and was unfit for use in this country. In the Ohio River valley and in the Great Lakes region and westward the plants from such seed are not winter hardy, and in the southern part of the clover belt they are more subject to disease than American plants. Not all imported red-clover seed can be condemned as wholly unfit for use in this country, but it can be confidently stated that American-grown seed will usually give better results than imported seed. An increase in the production in the United States of red-clover seed is highly desirable, since many of the failures experienced during recent years have been due to the use of imported seed, and not enough American seed is produced to supply the demand. When buying from dealers, farmers should insist on knowing the source of the seed and should use American seed whenever possible.

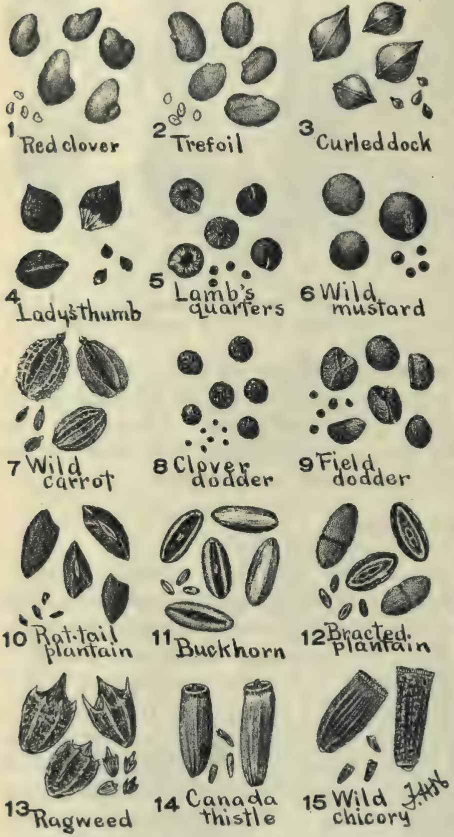


FIG. 6.—Seeds of red clover and common impurities.

SOILS AND FERTILIZERS FOR RED CLOVER.

Red clover is not a crop for extremely poor soils. On such soils more robust crops must be grown and turned under before a start can be had with clover. As a general rule throughout the clover belt any well-limed soil that will grow corn will grow clover. A deep, well-drained soil is desirable, as on a poorly drained soil red clover will not thrive; better sow alsike clover on such soils. Lack of nitrogen in the soil will not matter, since the clover will get nitrogen from the air.[4] Clover must have lime, phosphorus, and potash, however, and if the soil is poor in any of these it must be supplied before red clover can be expected to do well. The soil must also contain a reasonable proportion of organic matter. The limestone areas of the country are usually well suited to red clover, though even in these areas there are localities where the soil has become deficient in lime.

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[3] For further discussions of clover seed, seed testing, and weed seeds, see Farmers' Bulletin No. 676, Hard Clover Seed and Its Treatment in Hulling; Farmers' Bulletin No. 428, Testing Farm Seeds in the Home and in the Rural School; and Farmers' Bulletin No. 1161, Dodder.

[4] For a fuller consideration of this subject and of green manuring, see Farmers' Bulletin 1250, Green Manuring.

When lime is needed, burnt lime, hydrated lime, or finely ground limestone can be used. Roughly, their relative effectiveness is about as 100, 75, and 50, and if this relation is borne in mind, the cost when laid down on the farm will indicate which form is best to buy.

Many soils in the clover belt are poor in phosphorus, and this can readily be supplied by the use of 200 or 300 pounds of 16 per cent acid phosphate per acre. Potash is more rarely lacking, but there are soils, especially in the East, where this element must be added, and on such soils 50 to 100 pounds of muriate of potash per acre will prove very helpful. When the grain with which clover is seeded is fertilized the clover will usually make a good growth on the same fertilizer. Manure is very valuable for clover, both when used on the corn preceding the clover and later as a top-dressing. (Fig. 8.) There is nothing better than good stable manure. In the Pacific Northwest sulphur and gypsum have proved useful, and 75 or 100 years ago gypsum or land plaster was used a great deal in the East. It has now been replaced by lime and phosphates.

The questions of lime and fertilizers are largely local ones. The soils in the clover belt vary widely, and the various fields on the same farm may need different treatments. The most suitable treatment for each farm or each field is best determined by a test, and this can be made without a great deal of trouble. The accompanying diagram, Figure 9, illustrates how this can be done. In this outline no potash has been suggested. Potash plats can be inserted if desired, but over most of the clover area scarcity of phosphate is much more common than scarcity of potash, and by following the outline presented here the farmer is likely to find which fertilizer it is best to use. This has been so arranged that all the lime and all the manure can be applied to one continuous area. The phosphate alone must be applied to separate areas, and phosphate is the easiest to apply. A ton of ground limestone and 250 to 300 pounds of 16 per cent acid phosphate per acre is suggested unless the land is known to be very poor in lime, when 2 tons of ground limestone may be applied.

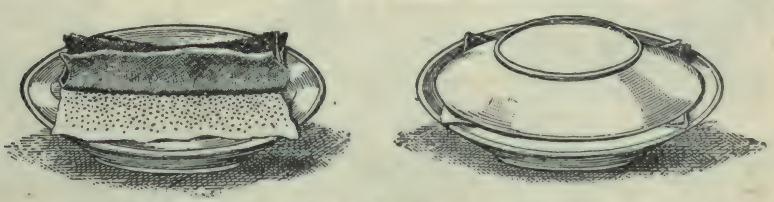

FIG. 7.—Homemade seed tester or germinator.

This outline (fig. 9) illustrates the principle of definite experimentation and can be varied to suit the kind of information wanted. One or more check plats to which nothing is added and which receive only the same treatment as the main field must always be left for definite comparisons.

SEED BED, SEEDING, AND NURSE CROP.

Clover seed is small and must have a fine seed bed, but while fine on top the bed must be firm. A loose seed bed is fatal to young clover; it dries out too fast. When clover is to be seeded on freshly plowed land the field should be worked several times with soil packers unless a heavy rain should intervene and pack the soil. On corn ground a good disking, perhaps followed by one harrowing, will usually put the seed bed in good shape.

Clover is most frequently seeded on winter wheat or rye or with spring grain. Of all these nurse crops, better called companion crops, oats is the most harmful, since its heavy growth makes a shade too dense for the young clover. When seeded on wheat the seed bed is usually in fair condition, and the clover seed may be sown on the ground when it is still freezing and thawing, as these processes will help to work the seeds into the ground. One successful practice is to sow half the seed in February. If there is a good stand no more seeding is necessary; if not, the remainder of the seed is put on in April. When seeding is delayed until the surface of the ground dries it is a good practice to harrow before and after seeding. The harrow if set to work about an inch deep will not hurt the wheat. Or the seed may be put in with a drill. This latter is the better practice, since less seed is needed and it can be put in at a fairly uniform depth. It is well to seed the clover crosswise of the wheat rows, which are best run north and south, as this enables the young clover to get the maximum light. Among seeders a wheelbarrow seeder or a seeding attachment to a 1-horse weeder are good tools. Among drills the special clover and alfalfa drill will give better satisfaction than a grain drill having a grass-seed attachment, especially when the clover is seeded alone, as on winter wheat. The clover-seed drill puts the seed in rows 4 inches apart and covers it to a more nearly right and uniform depth than can be done with a grain drill. If the clover seed is sown broadcast, 10 to 15 pounds per acre are used, but if drilled, only 6 to 8 pounds are needed. There are about 250,000 red-clover seeds in a pound, and evenly scattered on an acre 1 pound will leave five seeds on every square foot, enough for a good stand if every seed makes a plant. The extra seed is merely insurance, but

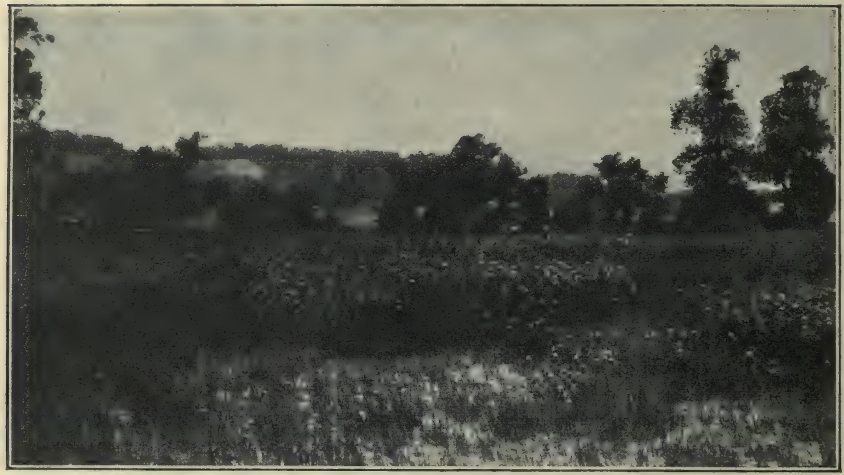

FIG. 8.—Red-clover field, showing the effect of top-dressing with manure. The area in the foreground received no manure; the area immediately behind received a light application, resulting in a very vigorous stand of clover.

this is valuable insurance. The conditions of seed, seed bed, and weather are perhaps never ideal, and allowance must be made for many chances of loss. Therefore, the more seed used, up to, say, 20 pounds per acre, the better the chance for a stand. Too little seed is used more often than too much, and unless seed is extremely high the extra dollar or so spent per acre to insure a stand of red clover is money well invested.

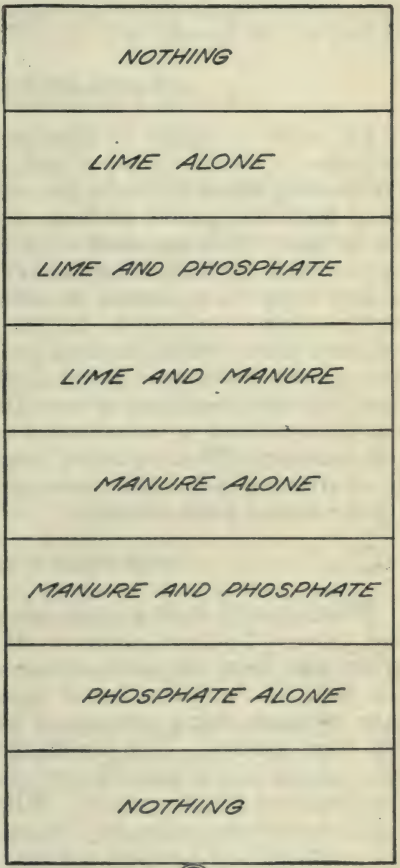

FIG. 9.—A simple experiment outlined to show what the land needs to grow clover.

When seeded with spring grain the clover seed is put in at the same time as the grain, but the grain is planted at a greater depth than the clover. On heavy land clover seed should be placed not more than an inch deep, but on light soils 1½ to 2 inches. The companion crop, especially if it be oats, should be seeded at only one-half to two-thirds the usual rate if the clover is to have a good chance for success.

The advantage of using a companion crop is that a grain crop is produced, avoiding the loss of the use of the land for a season, and, too, the grain keeps down the weeds. The stubble of the grain also serves as a winter protection to assist in catching and holding the snow, which otherwise might drift from the field and render the clover plants more likely to be winterkilled. However, the companion crop interferes somewhat with the growth of the clover, and on land where a stand of clover is badly needed and hard to get, it is better to prepare a good seed bed and sow the clover alone. Clover is sometimes seeded in corn at the last working, and this practice has been found very successful in parts of New England. Generally it is risky, since success depends upon good rains coming at that particular time.

As far north as central Indiana late-summer seedings are quite successful. Seeding in late summer has the advantage that the grain stubble can be plowed and thus the Hessian fly, wheat jointworm, and other insects destroyed. Of course it means more work, and only a study of local conditions can determine whether such practice will be economically justifiable. When seeded alone clover should be put on fairly clean land. Spring or early-summer seeding without a companion crop can not be practiced on very foul land, as the weeds will get the best of the clover; but when the weeds are not too thick they may be held back by clipping. The method adopted in any locality must depend on the rotations followed and the labor and weather conditions in each place. It may be emphasized here, however, that to get a good stand the clover must have a fair chance. As usually seeded, too little attention is paid to the weakness of the young clover plant and to its needs. In the clover belt clover is important enough to warrant special care in selecting the seeding method best suited to the special soil and to the other conditions prevailing.

INOCULATION OF RED CLOVER.

In order to make its best growth, the red-clover plant must be supplied with nitrogen-gathering bacteria on its roots. The tubercles containing these bacteria are shown in Figure 3. Fortunately, this crop has been grown so long in this country that most soils appear to be fairly well supplied with these germs, and usually no artificial application of them is necessary. When the clover is being tried as a new crop in a section it often does not become well inoculated until it has been grown for two or three seasons on the same piece of land, after which natural inoculation takes place and good crops are grown without further difficulty. When seeding clover upon land for the first time, it is well to provide for artificial inoculation, but after clover is established on a farm this procedure is usually unnecessary. This artificial inoculation may be accomplished either by scattering soil from some old, healthy, weed-free clover field or by the use of pure cultures.[5]

TREATMENT THE FIRST SEASON.

When seeded with a grain nurse crop no special treatment is given the clover the first season. It develops in the stubble after the grain has been cut and occasionally may afford some pasturage in the fall. If the late summer be especially favorable sufficient growth may be made for a cutting of hay, and in some cases a crop of seed has been secured. The stand, however, is likely to be injured by the cutting, and it is usually best to clip back the growth to check the development of the plants. When seeded in the fall in corn or with rape one or two crops may be expected the next season. It is usually not advisable to pasture spring seedings the same season with sheep or hogs, as they are likely to injure the young plants. Pasturing with cattle is less injurious.

TREATMENT THE SECOND SEASON.

Common red clover lives as a rule but two years. The second season the first crop is usually cut for hay and the second crop for seed. The aftermath, or rowen, is then pastured or plowed under. In sections where the season is not long enough to permit the clover to set seed after a full hay crop has been harvested, it is necessary if seed is desired either to pasture back the first crop of clover or to cut it early when just coming into bloom, rather than to wait until it is in full bloom, as is usually recommended. When mixed with timothy the stand is often allowed to remain three or four years with the clover gradually decreasing. The increase of pests, such as root borers and fungous diseases, makes it undesirable to try to keep a red-clover stand for more than one crop season. Even on the irrigated fields in Idaho such a practice seldom pays and is not to be recommended.

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[5] A limited quantity of pure culture for inoculating legume seed can be obtained free from the Office of Soil Bacteriology of the Bureau of Plant Industry, United States Department of Agriculture. Full directions for using the culture accompany each bottle. Directions for inoculating by the soil-transfer method can also be obtained from the office mentioned.

HANDLING THE RED-CLOVER CROP.

RED-CLOVER HAY.[6]

Time of cutting red-clover hay.—In order to obtain the best hay, the clover crop should be cut as a general rule when just past full bloom. At this stage a maximum of protein and dry matter is present; the leaves are still intact and the stems green. After this stage the leaves begin to fall and the protein content is in other ways reduced. It frequently happens, however, that due consideration for the success of the second crop, which is ordinarily allowed to stand for seed, makes it necessary to cut the first crop somewhat earlier than at the best haying stage in order to avoid injury from certain insect enemies. The disadvantage of cutting for hay before it is in full bloom is that the plants are then quite sappy and considerably more difficult to cure into a good quality of hay.

Methods of harvesting red-clover hay.—The methods of harvesting red-clover hay vary somewhat in different sections of the country. It is desirable to handle the hay so that it will reach the barn or stack with the least possible exposure to the weather and the minimum loss of leaves. Clover should not be allowed to become too dry in either the swath or the windrow, else the leaves will crumble, resulting at best in a very dusty hay, to say nothing of the loss of much of its nutritive value.

The secret of successful haymaking lies in rapidly reducing the natural moisture of the plant from 70 or 75 per cent to 15 or 20 per cent. As soon as the plants are cut the leaves lose water and draw on the stems for more. The first sign of this is when the leaves wilt. If they dry too fast because of a hot sun the leaves are killed prematurely; they stop pumping water out of the stems, become brittle, and break off easily, resulting in loss. Keeping the leaves alive and giving all the plants in the swath as nearly an equal chance as possible to get rid of moisture is the whole art of curing hay. Hence, the value of the tedder, if used before the top leaves get too dry. This machine stirs up the cut clover and gives all the leaves a chance to dry evenly and rapidly.

If the hay can be cocked before the leaves are entirely dry the movement of the water from the stems through the leaves will continue. When the leaves become well wilted in the swath the clover should be raked into windrows and then bunched into cocks when the hay is about half dry. Each cock should contain only enough hay so that two men can place the entire cock on the wagon at once, as in this way the loss of leaves due to handling is reduced to a minimum. Where a prime or choice quality of hay is desired and the rains are frequent, hay caps for the cocks and canvas covers for any outside stacks are valuable devices. These hay caps can be made from a 40-inch square of canvas or duck and may be held in place by small weights attached to each corner. Cement weights about the size of a baseball which may be attached to the hay cap by means of a hook and eye are satisfactory.

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[6] For the details of handling hay crops, consult Farmers' Bulletins Nos. 943, Haymaking, and 987, Labor-Saving Practices in Haymaking.

One successful method of curing hay is to cut the clover when half the blossoms are dead. The mower is run the entire day. The next morning, after the dew is off, the hay is raked into windrows, put into medium-sized cocks, and allowed to remain for 24 to 36 hours. The hay is forked over once to prevent heating and is then put in the barn. In threatening weather the hay is put into the barn at the end of 24 hours, but it is preferable to leave it in the field for a somewhat longer time.

Another method which has been successful under favorable conditions is to mow as soon as the dew is off, endeavoring by 11 o'clock to have enough cut to last the haulers from 1 to 5 o'clock in the afternoon. The newly cut clover is shaken up with a tedder before noon. At 1 o'clock it is raked into windrows, immediately bunched with the rake, and hauled into the barn. By this method the hay remains warm and free from outside moisture. The hay must be put in before 5 o'clock or the falling dew will deposit sufficient moisture to cause the hay to mold during storage in the barn. Handled in this way clover loses none of its leaves; but it is necessary to use extreme care to prevent having any outside moisture on the hay or heating in the mow is liable to take place. For this method to be a success excellent haying weather is necessary.

Importance of the leaves for hay.—The leaves are much richer in protein than the stems. While they constitute on an average only about 40 per cent of the total weight of the plant, they contain nearly two-thirds of the protein of the whole plant. Owing to improper methods of harvesting and to untimely rains one-half of the leaves may be lost, thus resulting in a marked deterioration in the feeding value of the hay. Table 1 shows the results of the analyses of hay from a single plant of red clover cut when one-fourth the blooms had turned brown and cured under cover.

TABLE 1.—*Results of analyses*[1] *of the different parts of a dry red-clover plant.*

Constituents.	Heads.	Stems.	Leaves.	Leaf-stalks.
Protein.....per cent..	18.25	8.06	24.63	11.16
Moisture.....do....	9.99	8.02	8.70	8.88
Ash.....do....	7.20	5.67	8.39	8.02
Ether extract (fat).....do....	2.86	1.25	5.00	2.18
Crude fiber.....do....	10.29	34.94	13.36	13.08
Nitrogen-free extract.....do....	51.41	42.06	39.92	56.68

[1] Analysis made by the Bureau of Chemistry.

Stacking red-clover hay.—The same general rules used for stacking other hays apply to the stacking of red-clover hay; but it must be remembered that red clover sheds water much less readily than the grasses and for this reason greater care is necessary in building and protecting the stack from the action of rain. It is advisable to build some kind of foundation for the stack. This foundation may be composed of poles or rails or some less valuable hay. By care in stacking, a comparatively large bulge may be put on the sides of the stack. This reduces the proportion of the hay in the stack bottom and causes the rain to drain off at some distance from the base of the stack. By keeping the middle full and well trampled the hay will settle in such manner as to cause the water to run off rather than into the stack. As red clover absorbs moisture readily the hay which lies next to the ground is almost sure to be spoiled. If canvas covers are not available for covering hay which must be left outside, it is an excellent plan to top the stacks with green grass, straw, or millet. After the stacks have settled they should be retopped with more grass or straw, placing an additional layer as far down the sides of the stack as possible. This materially reduces the quantity of clover hay exposed to the elements.

When the hay is stacked or stowed away in the barn in a slightly damp condition it is sometimes the practice to mix salt with it for the double purpose of salting the animals and of preventing mold. If the clover must be put up when thought to be a little too green, alternating layers of straw will do much toward absorbing the excess of moisture.

Brown clover hay is made by stacking or mowing away the hay when it has just reached the wilting stage. The air is excluded and it becomes a compact mass. The hay must be free from external moisture if heating is to be avoided. There is therefore some danger of spoiling when this method is used by those unfamiliar with the process. This method has a further disadvantage in that the hay is very heavy at the time when it must be handled for stacking.

Spontaneous combustion of red-clover hay.—When red-clover hay is stacked or mowed with any external moisture on it, such as dew or rain, heating is inevitable until not only the hay itself is damaged, but the heating process may go so far as to cause the entire mass to ignite and burn the stack or the barn in which the hay has been placed. The absence of air from the mass of heated hay in a barn is often the only thing which prevents it from breaking into a flame, and such instances are made manifest the following winter by finding charred masses within the interior of the mow.

RED CLOVER FOR SILAGE.

Silage has been made from red clover as from other legumes, but the process is always risky and rarely satisfactory. The relatively low sugar content of clover results in poor fermentation, and clover silage is likely to be slimy and unfit to feed. There is also a considerable loss in nutrients. On the whole, the making of silage out of red clover can not be recommended. When necessary to do so it is best to mix the clover with grasses, to cut it fine, and to trample carefully.[7]

RED CLOVER AS PASTURE.

Red clover is a most excellent pasture for all livestock, especially while they are growing. For pigs it should be supplemented with a small grain ration, as this will induce much more rapid gains. The early growth of red clover is less nutritious, pound for pound of green matter, than when near or at the blooming stage, since in the early stages of growth it is high in moisture content, thus requiring the animals to eat relatively larger quantities. Furthermore, close early pasturing is injurious to the stand of clover.

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[7] See Farmers' Bulletin 578, The Making and Feeding of Silage.

Ordinarily red clover will furnish some pasture during the first fall after spring seeding. It should not be too closely grazed at this time, else the succeeding season's hay crop may be decreased. The plants should rather be allowed to go into the winter with some growth upon the crowns in order to prevent winterkilling and also to enable them to store up material in the roots for an early vigorous growth the following spring.

Bloating.—When pasturing cattle or sheep on red clover, care must be taken not to pasture when the animals are very hungry, especially when the clover is young and succulent or when wet with dew or rain, as bloating may result. Should bloating occur, several remedies are usually at hand which will afford material relief. A large bit, the diameter of a pitchfork handle, may be tied in the mouth; a piece of rubber tubing may be passed through the mouth to the first stomach; or, as a last resort, the animal may be tapped to allow the escape of gas. For this purpose a trocar, such as is used by veterinary surgeons, is best; but in the absence of this a small-bladed knife may be used to make the incision about 6 inches in front of and slightly below the left hip bone. A straw or quill may be used to permit the escape of gas. Care should be taken not to allow the straw or quill to work down out of sight into the incision.[8]

When cattle are pastured on any crop that may cause bloating they should have free access to some form of dry roughage, such as hay, oat straw, clover straw, or corn fodder.

RED CLOVER AS A SOILING CROP.

Where pasturing is impracticable, red clover is often used as a soiling crop; that is, cut and fed green to livestock. Feeding in this way reduces or eliminates the danger from bloating which attends the use of red clover as pasture. It makes a good early feed, is palatable, and from 6 to 10 tons of green feed per acre is not an unusual yield.

RED CLOVER AS FEED.

All farm animals require protein in some form in order to make their best growth or to produce the best results either in the form of milk and butter, as in the case of dairy stock, or as eggs, in the case of poultry. Such roughage as corn stover and ordinary grass hay is low in the necessary protein. On many farms this protein is supplied by feeding concentrates, such as bran, oil meal, or cottonseed meal; but these concentrates are expensive and on most farms should be in large measure replaced by a leguminous forage crop, such as red clover, which can be grown on the place.

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[8] See Diseases of Cattle, a special report of the Bureau of Animal Industry, United States Department of Agriculture, which can be purchased from the Superintendent of Documents, Government Printing Office; price, $1.

Red clover is one of the most nutritious of forage plants, either in the green state or cured as hay.

Table 2 shows the average quantities of dry matter, protein, carbohydrates, and fat in 100 pounds of a few standard feeds. It will be noted that the clover hay contains more than twice as much protein as timothy hay and is therefore a more valuable feed, especially for young stock and for dairy cows.

TABLE 2.—*Digestible nutrients in red clover and other forage crops.*[1]

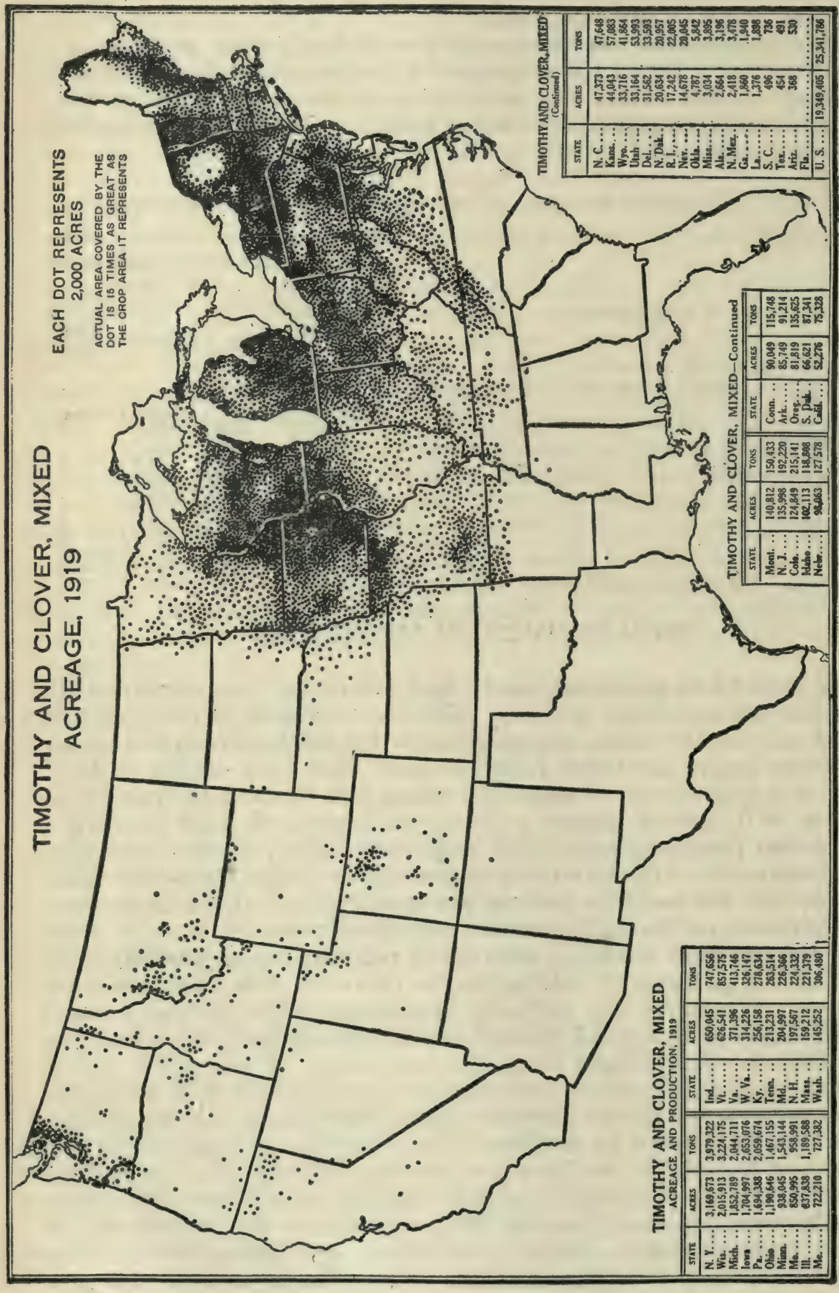
Kind of forage.	Dry matter in 100 pounds.	Digestible nutrients in 100 pounds.		
		Protein.	Carbohydrates.	Ether extract (fat).
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*
Fresh clover	28.0	2.6	12.2	0.7
Fresh alfalfa	27.1	3.6	11.8	.4
Clover hay	87.1	8.3	38.6	2.0
Alfalfa hay	91.7	11.5	39.4	1.1
Timothy hay	87.5	3.3	41.6	1.3
Cowpea hay	90.3	11.9	34.5	1.1
Wheat bran	90.4	12.5	42.8	2.6
Shelled corn	87.1	7.1	66.5	3.7

Figures furnished by the Bureau of Animal Industry.

RED CLOVER IN MIXTURES.

It is very often advantageous to seed red clover in a mixture with other clovers and tame grasses. The root systems of the different species are not the same, and as a result the soils of both the upper and lower layers are more fully occupied than they would be by a stand of a single crop. In case the stand is to be used for pasture, a mixture will usually insure a better succession of good pasturage than would the use of any single crop; that is, by proper selection of the constituents of the mixture it is possible to obtain a pasture which will provide for early as well as late grazing and at the same time give fair returns during the heated months of summer.

By far the most common mixture is red clover and timothy (fig. 10), but the practice of adding alsike clover to this mixture is increasing. Whenever any difficulty is experienced in getting a stand of red clover it is a good plan to replace about half the red-clover seed with an equal weight of alsike-clover seed. While alsike clover will not yield as heavily as red clover when the latter does well, it is more certain to catch on soils which are poor in lime. In the winter-wheat section, except in the South, the timothy is seeded with the wheat and the clover on the wheat the next spring. In the spring-wheat section the timothy is seeded with the red clover at the same time the wheat is sown, mixing 10 to 12 pounds of timothy with 8 to 10 pounds of red clover or of red clover and alsike clover. The timothy is longer lived than the red clover, and as a result the proportion of timothy in the mixture of the hay increases very rapidly after the second season. Ordinary red clover matures about two weeks earlier than the timothy, and for this reason mammoth clover, being about two weeks later, is frequently used for seeding in mixtures with the timothy.


TIMOTHY AND CLOVER, MIXED
ACREAGE, 1919
EACH DOT REPRESENTS 2,000 ACRES
ACTUAL AREA COVERED BY THE DOT IS 15 TIMES AS GREAT AS THE CROP AREA IT REPRESENTS

TIMOTHY AND CLOVER, MIXED
ACREAGE AND PRODUCTION, 1919

STATE	ACRES	TONS	STATE	ACRES	TONS
N. Y.	3,169,673	3,979,322	Ind.	650,045	747,656
Wis. ...	2,015,913	3,224,175	Vt.	626,541	857,575
Mich. ..	1,852,789	2,044,711	Va.	371,396	413,746
Iowa ...	1,704,997	2,653,076	W. Va...	314,226	326,147
Pa.	1,694,388	2,059,674	Ky.	256,158	278,634
Ohio ...	1,190,646	1,467,155	Tenn. ..	213,231	263,514
Minn. ..	938,045	1,543,144	Md.	204,997	226,366
Mo.	850,995	958,991	N. H. ...	197,567	224,332
Ill.	637,838	1,189,588	Mass. ..	159,212	221,379
Me.	722,210	727,382	Wash. ..	145,252	306,480

TIMOTHY AND CLOVER, MIXED—Continued

STATE	ACRES	TONS	STATE	ACRES	TONS
Mont. ..	140,812	150,433	Conn. ..	90,049	115,748
N. J. ...	135,998	192,220	Ark.	85,749	91,214
Colo. ...	124,849	215,141	Oreg. ...	81,819	135,625
Idaho ...	102,113	118,888	S. Dak. .	66,621	87,341
Nebr. ...	98,063	127,578	Calif. ...	52,276	75,328

TIMOTHY AND CLOVER, MIXED
(Continued)

STATE	ACRES	TONS
N. C. ...	47,373	47,648
Kans. ...	44,043	57,083
Wyo. ...	33,716	41,864
Utah ...	33,164	53,993
Del. ...	31,562	33,593
N. Dak. .	20,634	20,957
R. I. ...	17,242	22,005
Nev. ...	14,678	20,045
Okla. ...	4,787	5,842
Miss. ...	3,034	3,895
Ala.	2,664	3,196
N. Mex. .	2,418	3,478
Ga.	1,860	1,940
La.	1,376	1,898
S. C. ...	496	736
Tex.	454	491
Ariz. ...	368	530
Fla.	....	....
U. S. ...	19,349,405	25,341,786

FIG. 10.—Outline map showing the acreage in 1919 of mixed timothy and clover, which constitute the standard mixed hay throughout the northern part of the United States as far west as Iowa and Minnesota.

For commercial purposes red clover and alsike clover are much preferred, particularly when mixed with timothy. The trade objects to mammoth clover on account of its coarse texture and somewhat woody nature. The United States grades for timothy and clover and their mixtures class mammoth clover with other legumes, of which a total of only 5 per cent is permitted in any grade. Mixtures of red clover and alsike clover with grasses other than timothy are also discriminated against both in price and demand.[9]

Other mixtures suitable for hay are red clover combined with orchard grass, tall meadow oat-grass, and a small admixture of alsike clover. In any low spots in the meadow it is advisable to replace the orchard grass with redtop and at least half of the red clover with alsike clover. On rough-land pastures red clover may also form a minor constituent of a regular mixture of bluegrass and white clover.

The importance of the timothy-clover mixture may be judged from the figures in Table 3, in which the acreages of all the tame-hay crops harvested in 1909 and in 1919 are compared with the acreages said to have been in timothy and clover. The figures were calculated from data in the census reports for 1910 and 1920.

These figures may not show the exact relation of timothy and clover hay to all the tame hay as determined by the United States Department of Agriculture hay grades, since wherever the clover has failed or nearly failed in a mixed seeding pure timothy hay would result. However, it is probable that with alsike clover used largely in the mixtures the acreage figures will apply fairly well to the hay as graded.

TABLE 3.—*Ratio of the acreage of timothy and clover to the total acreage of tame-hay crops in 1909 and 1919.*

States.	Ratio to tame-hay crops (per cent).		States.	Ratio to tame-hay crops (per cent).	
	In 1909.	In 1919.		In 1909.	In 1919.
New England	50.13	59.1	Kentucky and Tennessee	22.07	19.72
Middle Atlantic	60.23	60.3	East North Central	41.33	48.9
Delaware, Maryland, Virginia, and West Virginia	46.67	51.66	Minnesota, Iowa, and Missouri	52.79	47.76

RED CLOVER AND SOIL IMPROVEMENT.

One reason for the great popularity of red clover is the ease with which it lends itself to the rotations which have long been practiced in the sections to which it is adapted. While sweet clover is replacing red clover in some localities and alsike clover is used in whole or in part on many soils on which red clover no longer does well, generally speaking red clover is the standard leguminous crop in the rotations in the northeastern quarter of the United States.

On farms where cattle are kept the clover, of course, makes the standard hay, and on such farms the first crop is cut for hay and the second may be allowed to make seed or may be turned under. On good soils and where clover is regularly successful in the rotation the turning under of this second growth will usually keep the soil in good condition so far as organic matter and nitrogen are concerned. P. E. Brown, at the Iowa Agricultural Experiment Station, has shown that red clover may take more nitrogen from the air than is removed in the hay and that therefore the mere turning under of the roots and stubble may improve the soil. The Delaware Agricultural Experiment Station found that 30 per cent of the money value of the fertilizer contained in red clover was in the roots. Red clover is therefore better suited than most legumes to a place in the rotation which requires the removal of the parts above ground and the use of the stubble and roots for keeping up the yields of other crops. However, it must not be thought that such a system can be continued indefinitely, except possibly on very rich soils. It has been found that on many soils the turning under of the roots and stubble only once in three years is not enough to maintain yields.[10] It is chiefly this soil-improving quality that makes red clover so valuable as a rotation crop. Other crops can be used for hay, but no other crop lends itself so well to hay production and to soil improvement in relatively short rotations.

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[9] This paragraph was furnished by the Chief of the Bureau of Agricultural Economics.

A red-clover field may be handled in various ways, but in view of the fact that clover is grown not only for hay but for soil improvement it will be pertinent to note the different methods of handling the clover with reference to the good of the land. The entire crop may be turned under for soil improvement. This is rarely done, but the manager of the Notre Dame University farm (South Bend, Ind.) does this regularly on the poor sandy soil of that place and insists that it pays to do it. The next best method and the one that will be applicable in most cases is to cut the first crop for hay, to be fed on the farm, and to turn under or to pasture the second crop. Another method that also yields good results and is especially useful where the pasture is not needed is to cut the first crop for hay and the second for seed and to return the straw to the ground. The objection to returning the chaff to the ground is that this gives a chance for the clover-seed chalcis fly to develop in the light seed that has been blown out with the chaff and so tends to increase the damage from this pest. From the standpoint of soil improvement the most unsatisfactory method is to cut both crops and leave only the stubble of the second crop to be turned under. However, even in such a case, especially if the second crop is cut for hay as early as possible and the field not plowed until the next spring, there will be considerable growth to add to the soil. Where the hay is not needed an excellent method is to pasture until late May or clip the field and then allow a seed crop to grow. By this method damage from insects is reduced to a minimum, and a fair to good seed crop may be confidently expected. The aftermath can then be plowed under or grazed if pasturage is needed.

RED CLOVER IN ROTATIONS.

In the northeastern United States the common rotations include a cultivated crop, a small-grain crop, and clover, or clover and grass. These rotations may be of various kinds and may include one or two crops of corn or other cultivated crop, one or two crops of small grain, of which one or both may be fall or spring seeded, and the clover or clover and grass stand may be left for one, two, or more years. In such rotations clover is commonly seeded with the small grain and turned under for the cultivated crop, usually corn. This procedure starts the clover without extra cost and with the benefit of whatever fertilizer is applied to the small grain, and the sod in decaying affords a steady supply of nitrates to the corn throughout the summer. The utilization of the sod in this way is the most economical and efficient. In long rotations clover may be grown but one year in four or five. Unless the soil is exceptionally rich such rotations will in time exhaust the organic matter in the soil and with it the nitrogen, and the land will run down and presently refuse to grow clover.

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[10] See Farmers' Bulletin 1250, Green Manuring.

In a system of grain farming the chief purpose of the clover in the rotation is to help in maintaining soil productivity. On such farms mammoth clover is advantageous, since a crop of seed can be taken as a cash crop and the straw, stubble, and roots turned under, in this way removing the least possible quantity of organic matter from the field and still getting some return. On such farms, too, sweet clover of late years has replaced red clover to a considerable extent. Seeded with a small grain, the sweet clover is turned under the following spring for corn. Besides these more or less standard rotations in which clover is used, it is sometimes seeded in corn or alone on the disked cornland in spring, to be turned under at some later time for another crop of corn. In Minnesota red clover is often seeded with spring grain and turned under the same fall, when the land is prepared for the next grain crop.

RED-CLOVER SEED PRODUCTION.

Red-clover seed is produced in small quantities on a large number of farms throughout the clover area. In some sections, as in some of the Intermountain States, the production of seed is a regular business, but generally the production of clover seed is incidental. If conditions are right and there seems to be a good setting of seed the field is left for seed. If there is not a good prospect for a seed crop the clover is turned under, or it is cut for hay if this is needed or if the price is high enough to warrant making hay for sale. In some sections red-clover seed is taken from the first crop, but this practice is confined to special localities. A number of factors influence the yield of seed, but most of these are as yet imperfectly understood. It can be said in general that the ideal conditions for seed production are the following: (1) A strong, vigorous recovery after haying; (2) clear, warm, but not extremely hot weather at the time the second crop is in bloom; (3) an abundance of bumblebees and other pollinating insects; (4) the absence of injurious insects, such as the clover-flower midge and the chalcis fly; and (5) good harvesting and curing weather. The second, third, and fifth of these factors are wholly beyond human control and sometimes exert a profound effect. A hot wave when the clover is in full bloom may destroy a seed crop that looks promising. A vigorous recovery depends somewhat on weather conditions, but also on the stage of ripeness at which the hay is cut. If this is allowed to get overripe the plants do not recover well, while the earlier the hay crop is cut the better for the seed crop. As a specific instance it may be cited that mowing was commenced on one side of a 40-acre clover field when the plants were two-thirds in bloom. Several days were required to cut the field and the last of the clover was not cut until the plants were just past full bloom. The effect of this time of cutting on the seed crop was remarkable in that the early cutting induced the second crop to produce seed at the rate of 5 bushels per acre, whereas the cutting a week later resulted in a subsequent seed yield of only 2 bushels. The difference in the value of the preceding hay crop by reason of the early cutting on the one side was probably not more than 20 per cent, whereas its increase of the yield of seed was more than 100 per cent.

Early cutting will also help to control the injurious insects mentioned above in connection with the fourth factor, as the first brood of the season will be destroyed in the hay and there will be few adult females to bother the seed crop. The same object may be attained by pasturing the clover in the early part of the season and taking a seed crop only.[11]

In the northern portion of the northern tier of States the short growing season will not usually permit the first crop to reach full bloom and still allow time for a seed crop to mature. For this reason it is usually necessary to pasture the crop or cut it earlier than would otherwise be desirable. If a full cutting of the first crop of clover is made for hay and the second left for seed, the seed yield is likely to be disappointing on account of the lack of suitable growing weather for the seed crop. In the latitude of northern Michigan the clover may be pastured until June 18 or 20 in normal seasons and then allowed to produce seed. If livestock for pasturing is not available, the clover may be clipped back about the middle of June with equally good results. Even when the land is pastured it is a good practice to run the mower over the field after the stock is removed, to clip back any bunches which may be left by the stock. In this way the seed crop will mature much more evenly over the entire field.

ESTIMATING THE PROBABLE SEED CROP.

Inasmuch as clover straw is of little value as feed, if the crop is allowed to go to seed a decision must be made when the field is a little past full bloom as to whether the second cutting should be allowed to stand for seed or be used for hay. It is usually possible to estimate with fair accuracy the probable seed production by the time the plants are well out of bloom. If examination of the field shows a uniform stand of a goodly number of heads with an average setting of 25 to 30 seeds to the head, it may be taken as an indication of a sufficiently good crop to pay to cut it for seed, as under normal conditions this indicates a yield of 1 to 2 bushels per acre. If the heads which are turning brown show less than 20 seeds to the head, it will usually be better to cut the crop for hay, even though it is a little too late for the best quality of hay.

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[11] For an extended account of the clover-flower midge, see Farmers' Bulletin 971, The Control of the Clover-Flower Midge.

HARVESTING AND HULLING RED-CLOVER SEED.

The best time to cut red clover for seed is when the heads have turned brown and the flower stalks deep yellow and the seeds have begun to show a distinct violet color. If cutting is delayed until the heads are black or until the seeds have completely colored, the loss of seed from the breaking off of the heads is certain to be heavy. If the stems are heavy and full of sap, cutting can be done earlier than if the stems are short and dry, as the abundant sap will ripen the seed. When cut early, before the leaves are dead, the stems dry better and cure more quickly. Sappy stems when cut after the leaves are dead cure slowly and therefore cutting should be done before the leaves reach that stage.

Various machines are used for cutting clover for seed, but the most common are a mower with a windrowing attachment and a mower with a bunching attachment. The latter is best when the clover to be cut is dry, since the cut clover is then handled but little. The windrowing attachment is the most popular, as it puts the cut clover out of the way of the horses on the next round. (Fig. 11.) The old self-rake reaper is also popular. Farmers use various methods and different machines, but the principle to be kept in mind is to handle the crop between cutting and hulling as little and as carefully as possible. Every time a clover head is broken off some seed is lost.

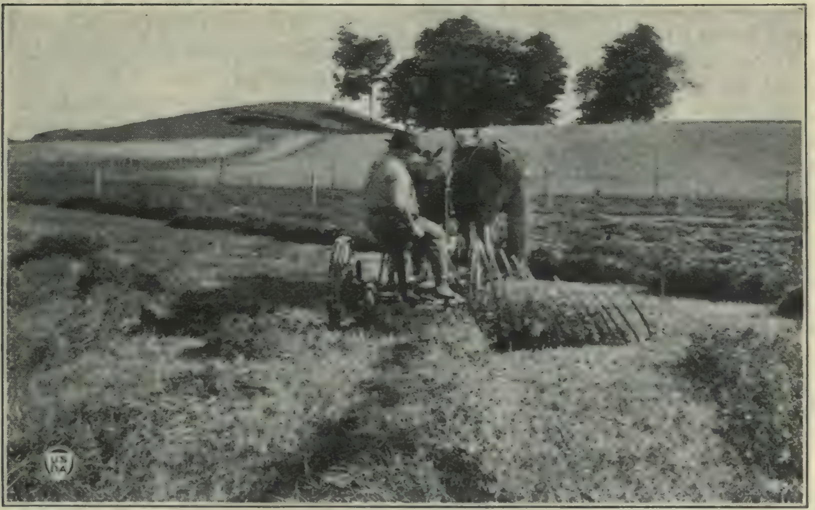

FIG. 11.—A mower with attachment which leaves the cut clover in windrows, out of the path of the horses on the next round.

The cut clover is allowed to lie in the field until partly cured and is then put into cocks. These should be small, not more than 2 or 3 bushel basketfuls in size. Large cocks will not dry in the center without being pulled apart, and that involves risk of loss. A somewhat prevalent idea is that the clover must rot in order to hull well, but this is not necessary. The important thing is that it must be thoroughly dry. Damp clover is tough and does not handle well.

The principles involved in the successful handling of the clover-seed crop are: (1) Cut when the seed is ripe enough, but when most of the leaves are still alive; (2) handle no more than is necessary; and (3) hull as soon as possible after the clover is thoroughly dry.

Any tools or methods that make it possible to handle the crop in this way are good tools and good methods. It is the usual practice to hull from the field, but if the clover must lie for weeks before a huller can be secured it is much better to put the dry clover in the barn or to stack it than to leave it in the field exposed to all sorts of weather. When the seed crop is stacked it is very important that the clover be bone dry; otherwise, it will remain damp in the center and will have to be torn apart and spread before hulling. This extra handling will entail the loss of seed. To protect the base of the stack 6 to 8 feet of dry straw should be placed on the bottom, and the stack should be carefully covered with grass hay or with a stack cover. When stowed in the mow the only care is to have the clover bone dry before bringing it inside. In damp clover a considerable quantity of seed may be lost by sprouting; in fact, more than would be lost by handling the crop during hauling and stacking. Besides the actually sprouted seed in damp rotting clover there is also a lot of seed that swells and is ruined. Many of these seeds are later blown out as light seeds, while others lower the value of the entire crop because they are brown and shriveled.[12]

Hulling clover is commonly done by special clover hullers. There are also clover-huller attachments to grain separators. A clover huller is simply an ordinary threshing machine equipped with an auxiliary cylinder and concave with rasps or other devices for rubbing off the hulls from the threshed seed. The huller will not do good work when the clover is at all damp even from dew; hence six hours is usually found to be a good day's run when hulling from the field.

UTILIZATION OF CLOVER STRAW.

After the seed has been removed the clover straw is too unpalatable to be of much value as feed, though sheep and cattle will pick it over during the winter. It may be scattered on the field from which it was cut with good effect on the land. The chaff may also be used as an absorbent of liquid in stables. It is an excellent plan to apply the clover straw and chaff to thin spots in the fields which are to be in clover the succeeding year. This method materially improves the inoculation and tends to increase the productivity of the clover and other crops.

If the clover is cut for seed and cured without having been rained upon, the straw has some feeding value, but such instances are unusual. When the first crop of clover is cut for seed the straw makes a fair feed.

RELATION OF POLLINIZING INSECTS TO THE PRODUCTION OF RED-CLOVER SEED.

Numerous experiments have shown that if the heads of red clover are bagged to exclude insects little or no seed is produced, indicating that without external assistance of some kind the red-clover plant is unable to set seed. It is possible that some seed may be produced when the pollen from a flower is placed on the stigma of that flower or on the stigma of another flower of the same plant. As a rule, however, red clover is self-sterile and for practical purposes is wholly so. In the open field the flowers are cross-pollinated. Bumblebees are commonly supposed to be the most efficient agencies in the pollinization of red clover. When the bee alights on the clover head its weight presses down upon the keel, forcing out the stigma (female), which becomes dusted with the pollen (male) that is already adhering to the under surface of the bee. Other species of wild bees, as well as honeybees, especially the long-tongued Italian strain, also play a great part in pollinating red clover. It has been shown experimentally that even when honeybees and smaller insects only had access to clover a good seed crop was set.

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[12] See Farmers' Bulletin 676, Hard Clover Seed and Its Treatment in Hulling.

VARIETIES OF RED CLOVER.

In North America there are but two standard varieties of red clover, medium and mammoth, though a third variety has been developed in Tennessee because of its resistance to anthracnose. This disease-resistant variety is in all other respects like the common red clover. Medium, June red, or common red clover is the standard clover in the United States and Canada. It is an extremely variable plant, but no special varieties except the disease-resistant one mentioned are in use. There has been some work done on selection, especially in Canada, but no seed of these new varieties or strains has yet appeared in the trade.

Mammoth clover, also known as Sapling clover, Big English, Pea Vine clover, Bull clover, and Perennial clover, is only a form of the ordinary red clover and is known botanically as *Trifolium pratense perenne.* It is not the "zigzag clover" of northern Europe, known as *Trifolium medium*, which latter name has often been misapplied to mammoth clover.

Mammoth clover differs from medium red in being about two weeks later to mature and in being under similar conditions larger and coarser. It is commonly more hairy and in the autumn of the first season blooms little or not at all. At this stage it can usually be distinguished in the field by its closer adherence to the low rosette habit. Only one crop of mammoth clover can be harvested each season, since it does not recover quickly. On the other hand, it is generally longer lived than common red clover and so is often used in pasture mixtures.

On low ground the stems of mammoth clover are likely to become somewhat woody. It grows less rank on poor soils, where it is ordinarily grown rather than on the heavier soils. Furthermore, on the poorer soils it is excellent as a seed-producing crop, being used in a rotation of corn, grain, and clover each one year. The mammoth clover is allowed to stand for seed, and no attempt is made to utilize the straw other than as a fertilizer for the land. The late maturity of this clover enables it to avoid many of the insect pests which greatly injure the fields of ordinary clover. This item is important in reducing the injury from the insects which play havoc with the successful production of seed of the ordinary red clover. If grown for hay mammoth clover should be cut when in early bloom rather than when past bloom, on account of the tendency of the stems to become woody. In the northern part of the tier of Northern States where only one crop of ordinary clover is possible mammoth clover is usually preferred on account of its higher yield.

While some men who have had long experience in the seed trade believe that they can tell mammoth-clover seed from that of common red, there are no absolute distinguishing marks. The seeds are of the same size and coloring, the variations observed in one form occurring also in the other.

Foreign red clovers.—In Europe several varieties or strains of red clover are recognized and are mostly known by the names of the countries or provinces where they are grown. European red clovers usually have smooth leaves and stems and therefore make a cleaner, less dusty hay than the American clovers. However, some European clovers are known to be not adapted to American conditions. So far as tested none of them give returns in this country equal to those from American clovers. The plants raised from seed of southern European regions are not winter hardy in the Ohio Valley and westward, and in the southern parts of the red-clover area they are more readily killed by disease than plants from American seed. Even where the stand of European plants has come through the winter successfully and has yielded a fair first cutting, the stand sometimes completely dies out after the first cutting. In no case has a second cutting compared favorably with the yield from American plants. Of late years much red-clover seed has been imported from Chile, and this has given better results than any other imported seed. The plants are smooth and in tests so far made have yielded a large first cutting. The behavior of the plants after the first cutting is, however, much like that of plants from European seed, and the aftermath and second cutting are likely to be disappointing.

ENEMIES OF RED CLOVER.

The principal enemies of red clover are insects, fungous diseases, and weeds. Under conditions favoring their increase, such rodents as field mice, ground squirrels, and pocket gophers become abundant and cause considerable damage.

INSECT ENEMIES.

Red clover is injured by a rather small number of kinds of insects, although some of these pests may at times be abundant enough to destroy the greater portion of the crop. Many insects which feed to a slight extent on this valuable plant are seldom or never sufficiently numerous to cause appreciable loss. For further information on the principal insect enemies of red clover the publications of the Bureau of Entomology of the United States Department of Agriculture should be consulted.[13]

The clover root-borer.—Great damage has resulted for many years from the work of the clover root-borer (*Hylastinus obscurus* Marsh) in the clover-producing States east of the Mississippi River. At one time this pest threatened the entire clover-growing industry of Michigan. In recent years this insect has become a serious menace to clover culture in western Oregon and Washington, where the production of clover is of considerable importance. The adult insect is a dark-brown hard-shelled beetle (fig. 12), about one-sixth of an inch long. Its presence is best indicated by the injuries to the root of the clover plant (fig. 13) caused by the larva, or grub, of the insect (fig. 14). The clover root-borer does not usually damage the stand of clover until the summer of the second year, because it is not until the roots of the plant become of considerable size that this pest is capable of living in them. For this reason, where practicable, a three-year rotation is desirable as a means of preventing injury from this pest. The only remedial measure yet suggested is the turning under of the clover stubble as soon as the hay crop is removed, preferably between June 15 and August 1. At this time the root-borers are in an immature stage, and when deprived of their food must perish, as they are incapable of migration. If plowing be delayed until later in the fall, the larvæ will then have become pupæ, or adults, and at this time they may be unaffected by plowing operations. Spring plowing of heavily infested fields has been known to cause severe injury by inducing migration to new clover.

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[13] Farmers' Bulletin 942, Controlling the Clover-Flower Midge in the Pacific Northwest; Farmers' Bulletin 971, The Control of the Clover-Flower Midge; and The Clover-Root Curculio, U. S. Dept. Agr., Bur. Entom. Bulletin 85, pt. 3, bibliography, p. 38.

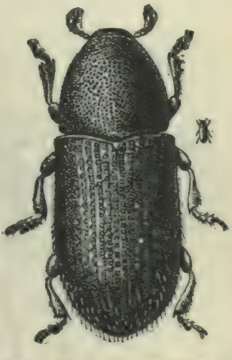

Fig. 12.—The adult insect of the clover root-borer. A natural-size representation is shown at the right.

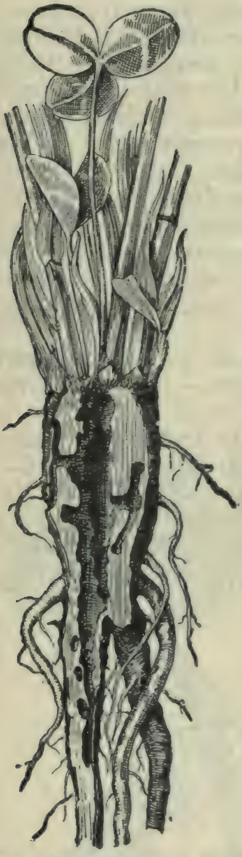

Fig. 13.—Clover root, showing the work of the clover root-borer. (Slightly enlarged.)

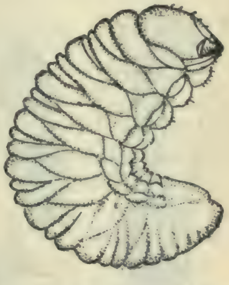

Fig. 14.—The larva (grub or maggot) of the clover root-borer. It is in this stage that the insect does most damage to the clover roots. (Much enlarged.)

The clover-seed chalcis fly.—A little black wasplike insect (fig. 15) about the size of the red-clover seed, known as the clover-seed chalcis fly (*Bruchophagus funebris* How.), may frequently be seen emerging from a recently threshed crop of this seed. At present this insect is one of the worst clover pests in the United States, being largely responsible for many of the low yields of clover seed. The eggs are laid in the newly developed seed before it is entirely hardened; the larva then develops within the seed, which it eats entirely away before emerging as the adult. (Fig. 16.) As this insect spends the winter to a large extent in the deformed and hollow seed capsules of the clover and alfalfa plants, it is most important that all screenings and débris resulting from the threshing of clover and alfalfa seed be destroyed, preferably by burning, as soon as practicable after the threshing is completed. It is probable that light early pasturing or clipping the first growth in the spring will materially reduce the danger from this pest; by bringing on the seed crop later than usual the destructive work of the insects may be largely prevented.

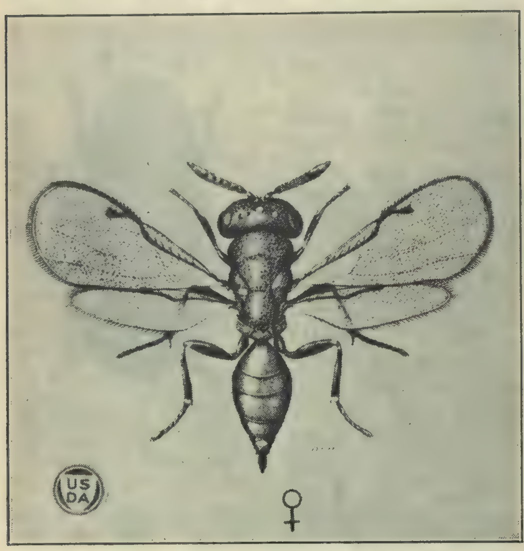

FIG. 15.—Adult insect of the clover-seed chalcis fly. The wings are ordinarily closely folded along the back. (Much enlarged.)

The clover-flower midge.—The seed production of red clover is greatly reduced at times by the work of the clover-flower midge (*Dasyneura leguminicola* L.). (Fig. 17.) The maggots of this insect attack the florets of the clover, thereby causing the distortion and stunting of the blossoms, which often becomes plainly evident throughout an infested field even when viewed from a distance. (Fig. 18.) The adult of this insect is a small mosquitolike fly, closely related to the wheat midge and the Hessian fly. This pest may be controlled by cutting the first crop of clover early enough to

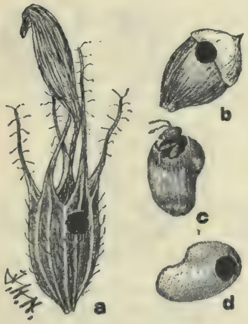

FIG. 16.—Sketch showing the effect of the clover-seed chalcis fly: Calyx (*a*), seed capsule (*b*), and seeds (*c* and *d*). At *c* the mature insect is shown in the act of emerging.

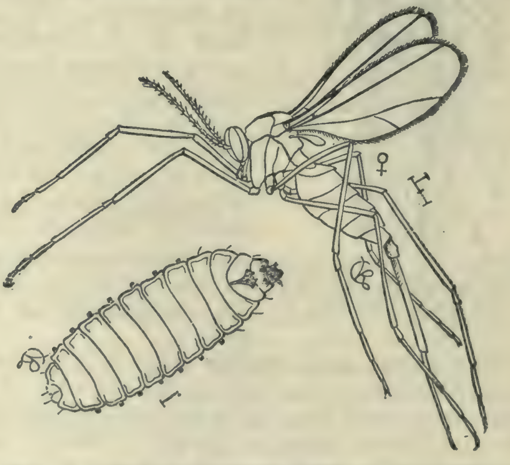

FIG. 17.—Maggot and adult stages of the clover-flower midge. In the clover head the maggot appears as a small red object one-twelfth of an inch in length.

catch the maggots before they are fully fed, thus depriving them of food and causing their destruction. Because of regional differences in the maturity of the insect and the crop, no definite date for cutting can be recommended, although it has been found that the first of June usually is suitable throughout most of the injurious range of this insect. The most satisfactory results are to be obtained, however, by observing the color of the maggots in the infested heads. When their color begins to turn from a creamy white to a salmon pink, the time for action has arrived, and if the pest is to be overcome cutting should occur within a day or two. Most of the larvæ will be killed, and the early cutting of the clover will so hasten the development of the seed crop that by the time such of the first brood as have survived here and there have matured, the blooms of the second crop have become too far advanced for the insects to work in them. A second method may be applied where timothy and clover are grown together. The meadows may be pastured lightly or they may be clipped back with a mower set high. This brings the blooming of the subsequent crop of clover too late for the destructive work of the midge.

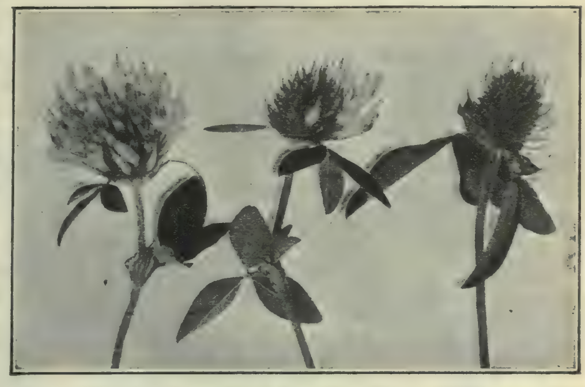
FIG. 18.—Clover heads, showing the effects of the clover-flower midge. The flower head shown at the left is unaffected, the middle head is partly affected, and the head at the right shows all the flowers destroyed by this insect.

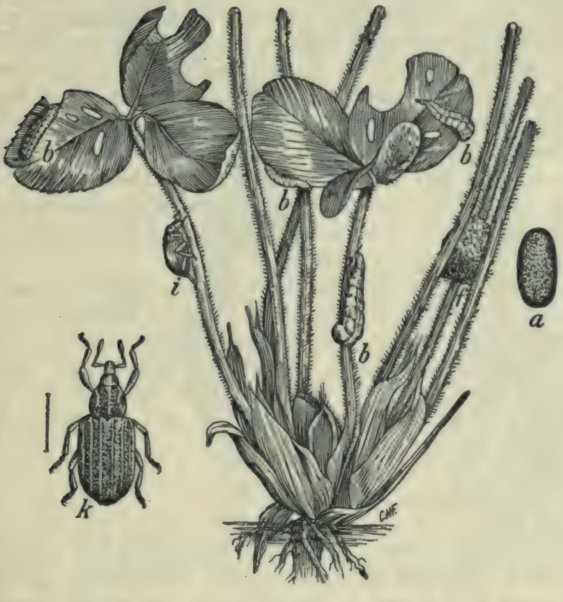

FIG. 19.—The clover leaf-weevil: *a*, Egg; *b*, *b*, *b*, *b*, larvæ feeding; *f*, cocoon; *i*, beetle, side view; *k*, same, back view; (*b*, *f*, *i*, natural size; others more or less enlarged.) Adapted from Riley.

The clover leaf-weevil.—Among the minor enemies of red clover is the clover leaf-weevil (*Hypera punctata* Fab.) (Fig. 19.) The larvæ begin to hatch in the fall and become full grown in April and May, and the adult insects appear from the last of May until the following October. This insect was formerly especially troublesome in Michigan until a fungous disease of the larva developed sufficiently to hold it in check.

One important effect of the clover leaf-weevil is that it may destroy the early foliage. A little later the clover renews its growth without being permanently injured. This delays the flowering period until after the flower midge has laid its eggs and disappeared. In this respect the weevil may be beneficial. The temporary destruction of the early foliage may lead the grower to believe that his clover field has been killed, and he may therefore plow up the stand, whereas really the injury will prove but slight if the field is left undisturbed. In case of excessive damage, the clover leaf-weevil may be destroyed by spraying the crop with arsenate of lead (powdered), 2 pounds mixed with 100 gallons of water, this quantity to be applied to 1 acre of the crop.

FUNGOUS DISEASES OF RED CLOVER.

A number of diseases attack principally the leaves of the red-clover plant, forming large or small spots of various appearances. The clover leaf-spot appears as a multitude of small black specks on the leaves. The clover rust shows as small reddish brown spots on the leaves. The powdery mildew develops a whitish mass somewhat like a cobweb across the surface of the leaves, and close inspection shows the presence of small black bodies within the meshes. None of these leaf diseases is usually very serious, and when the plants are growing vigorously they are generally able to thrive in spite of the presence of the fungous diseases. Cases have been known, however, where rust damaged the clover as much as 50 per cent. Mildew was unusually abundant in the fall of 1921 and in 1922, but feeding tests conducted at the Tennessee Agricultural Experiment Station showed that mildewed clover could be fed without damage to livestock.

Root-rot occasionally proves destructive to the roots of the clover plant. Stem-rot attacks the stems and is characterized by the presence of hard, dark masses of fungous tissue.

The disease known as clover anthracnose has been observed in a number of States, but its ravages have been observed to be especially disastrous only in Tennessee, where, owing to its prevalence, the seeding of red clover is said to have been practically given up. The disease is first manifested by a series of small purple patches which spread on the stem until if at all badly affected it is completely encircled, causing the death of the plant.

WEEDS.

The seeds of the weeds which are commonly found in red clover are shown in Figure 6. From the standpoint of the clover plant itself buckhorn, foxtail, and crabgrass probably form the worst weeds with which the clover plant must contend. Preventive measures alone are ordinarily practicable, as eradication is too expensive except in the case of especially dangerous weeds or weeds large enough to be readily removed just before they mature their seed crop. Thistles, dock, and wild-carrot plants should be removed.

Dodder is one of the worst weeds so far as red clover is concerned. The accompanying illustration (fig. 20) indicates the general appearance of the yellow threadlike vines which attach themselves to the clover plant. The dodder seeds germinate in the ground shortly after the clover seeds sprout. The yellow threadlike stem of the dodder soon firmly attaches itself to the young clover plant, after

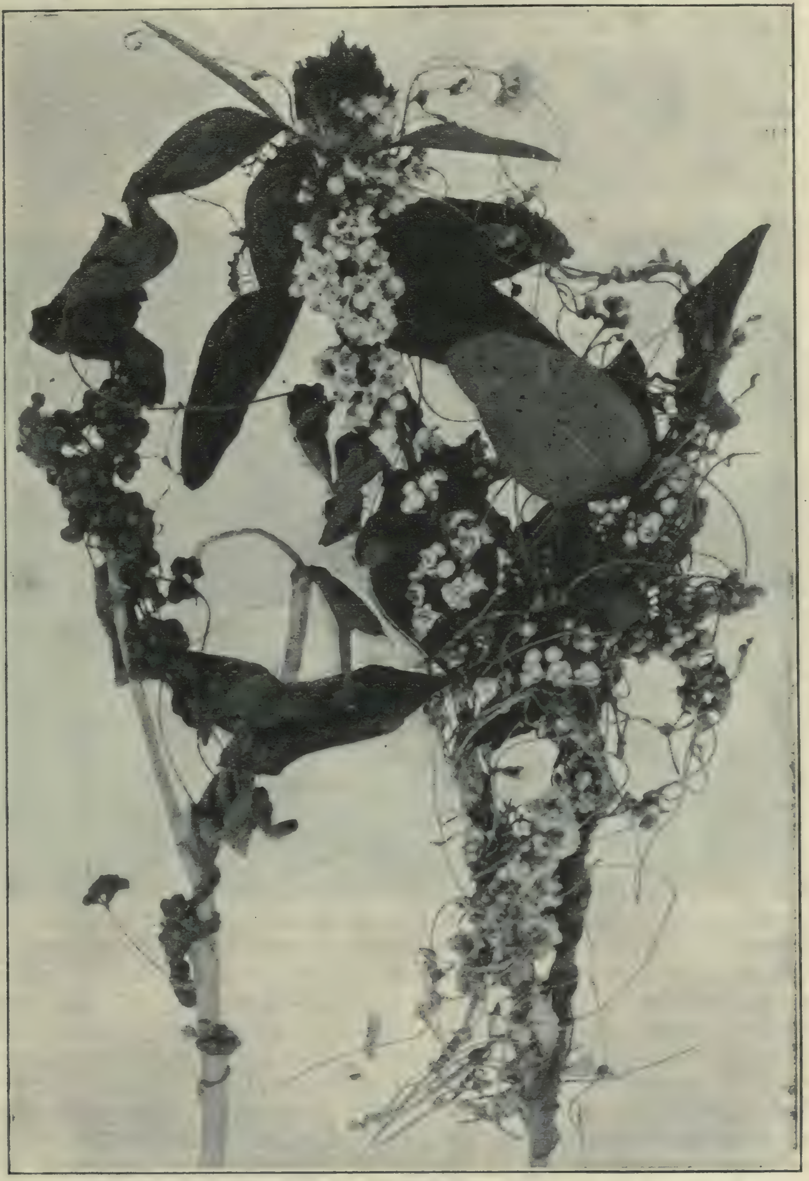

FIG. 20.—Field dodder on stems of red clover. At the right the dodder is shown in flower; at the left, in the mature or seed-producing stage.

which the stem connecting it with the ground withers away and the dodder lives thereafter entirely on the clover plant. Dodder is very difficult to eradicate when once established, and for this reason great care should be taken to avoid introducing it with the red clover at seeding time.[14] Close grazing has been recommended as being effective in holding dodder in check. If it appears in isolated spots throughout the field, it is advisable to cut the affected area as low as possible before any seed is produced on the dodder and to remove all cut material from the field. Destroying the dodder by burning with inflammable materials or by spraying with sodium arsenite are methods used in Idaho, where dodder is sometimes a serious pest in seed fields.

CLOVER SICKNESS AND CLOVER FAILURE.

Some confusion exists regarding the nature of clover sickness, a term which appears to have been applied to a great many different causes of clover failure. In Europe this term is used to designate the condition of the land when it fails to grow continuous crops of clover, but which will again grow successful crops after an interval of five to eight years. The clover sickness of Europe is caused by the stem rot or by a minute eelworm, or nematode. Both of these organisms occur in the United States and have caused considerable damage locally. The too frequent failure to get and hold a stand of clover in America is not true clover sickness, however, but is due to several causes. Perhaps the chief of these is lack of lime or of phosphorus in the soil. Another is loss of organic matter by reason of unwise methods of farming. Use of imported seed and in some sections diseases such as those mentioned on page 28 play a part, but there are no data to show how great is the responsibility of any one of these factors.

A better term than clover sickness is clover failure. There is no mistake about the fact that good stands of red clover have of late years been harder to obtain than formerly. Frequent clover failures have been experienced mostly in the East, but also as far west as Iowa. Many factors have worked toward this end, but they may be placed in five groups: (1) Soil exhaustion; (2) improper methods of seeding, nurse crops, etc.; (3) unfit seed; (4) diseases; and (5) improper treatment the first autumn. Clover fails more often because soils have become poor in lime, phosphorus, potash, or organic matter than for all other reasons. The method of plat trials suggested on page 7 will enable the farmer to get a good line on what his fields need. If lime is badly needed there is no use wasting clover seed. If phosphorus is the limiting factor the addition of lime alone, even if the land is "sour," will have slight effect. Manure will do good more often than anything else, but when lime is needed the results from manure will be much greater after this need has been supplied than before. By making the soil conditions such as favor the growth of clover, failure can nearly always be turned to success.

Improper methods of seeding, etc., are frequently responsible for the failure to get even the start of a stand or for the death of the plants after grain harvest. A poor seed bed, poor seed, weeds, careless seeding, or too heavy a nurse crop may all make for the early destruction of the small plants. The nurse or companion crop is frequently responsible for failure. If the season is dry the vigorous grain will take the moisture and leave the clover seedlings to dry up, or the tender plants can not endure the sudden exposure to a hot sun. Where the soil is rather hard it will help to top-dress the wheat with manure or to even scatter straw on the wheatland immediately after seeding to wheat.[15] (Fig. 21.) This will mulch the soil and help keep it cool and moist. The use of improper seed has already been referred to (p. 4). Of course, if dead seed is used there will be no stand, but foreign seed not suited to the section where it is to be seeded may give a good stand in the fall of the seeding year, and that stand may be gone by May of the following year. It seems probable that 10 per cent of the failures of clover from Ohio eastward may be caused by the use of such seed.

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[14] See Farmers' Bulletin 1161, Dodder.

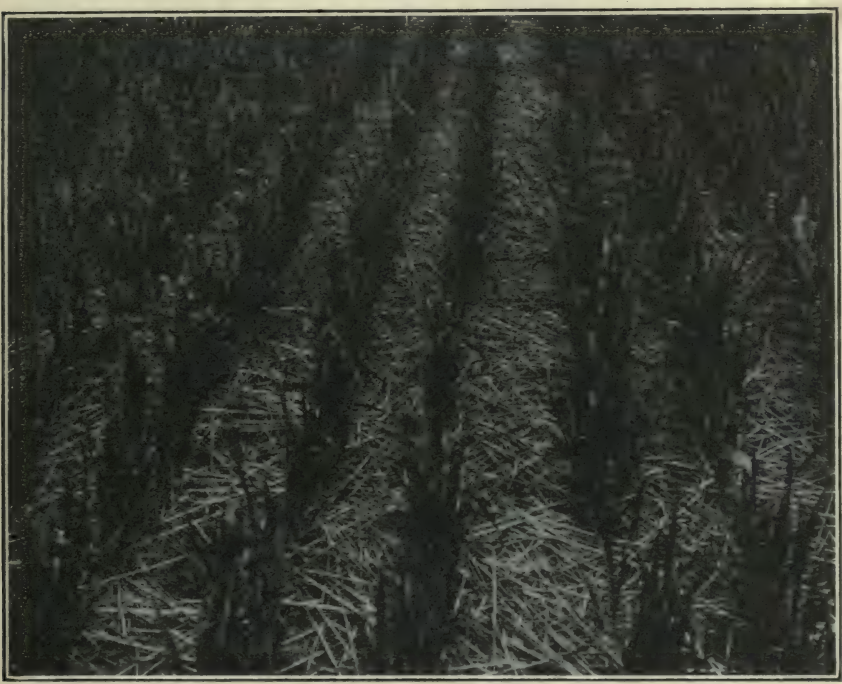

FIG. 21.—View of a wheat field on which straw has been scattered in preparation for clover seeding. The straw is put on soon after the wheat is sown, and the clover is seeded the next spring.

Diseases except in certain localities play a minor part in extreme failure. The total yield of hay may be cut down by the various insect or fungous troubles already mentioned, but the complete destruction of the stand before a crop has been harvested is not common. Even in Idaho, where the nematode, one of the causes of clover sickness in England, is sometimes serious, the crop is seldom destroyed outright or even materially hurt before June of the second year.

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[15] For an extended account of this method, see The Management of Clover in Corn-Belt Rotations, by J. A. Drake. Ohio Agr. Exp. Sta. Cir. 111, 19 p., 4 fig. 1911.

Where red clover can not be grown without the addition of lime or other soil amendments and where the application of these is for any reason impracticable, alsike clover should first be substituted for red clover, or it may be possible to grow mammoth clover for soil improvement after common red clover will no longer thrive, and by turning under the mammoth clover the soil may be restored to a condition in which it will produce a stand of red clover.

ORGANIZATION OF THE UNITED STATES DEPARTMENT OF AGRICULTURE.

October 8, 1923.

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U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1340

POLISH And POULARD WHEATS

1862 1889

POLISH AND POULARD WHEATS are two distinct species or subspecies of wheat of rather striking appearance which often have been fraudulently exploited in this country under many different names.

False stories of the origin of these wheats usually have accompanied the offers of seed for sale at prices ranging from $20 to $60 per bushel.

The one variety of Polish wheat grown in this country, White Polish, bears a resemblance to rye and has sometimes been wrongly sold as a variety of "giant" rye. It can be grown only in the spring-wheat region, and there it seldom yields more than half or two-thirds as much as other varieties. It is not used in the manufacture of bread-making flours or semolina products, such as macaroni and spaghetti.

Four varieties of poulard wheat have been grown in the United States in recent years, three of which have branched or composite heads. The Alaska is the best known and most widely exploited variety. Poulard wheat usually produces low yields and is not suitable for making flour or semolina.

Farmers are advised against buying and growing varieties of Polish and poulard wheat, as only unsatisfactory returns have been obtained from them in all parts of the United States.

Washington, D. C. Issued July, 1923

POLISH AND POULARD WHEATS.[1]

By JOHN H. MARTIN, *Agronomist in Western Wheat Investigations, Office of Cereal Investigations, Bureau of Plant Industry.*

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INTRODUCTION.

Man craves spectacular things even in a commonplace crop, such as wheat. Polish and poulard wheats are among our most spectacular cereal crops in appearance, and the stories which have accompanied the exploitation of these two grains would excite the interest of the most indifferent farmer. Neither of these wheats is of commercial value in America, but both have been offered many times and are still being offered to the buying public by unscrupulous or unknowing promoters who take advantage of their striking appearance.

This bulletin has been prepared to answer the frequent requests for information concerning the origin, productivity, and value of the varieties of Polish and poulard wheats grown in this country and to warn farmers against paying high prices for seed of these nearly worthless grains.

POLISH WHEAT.

Polish wheat, known botanically as *Triticum polonicum* L., comprises a distinct species of the wheat genus and is strikingly different from the kinds commonly cultivated in this country.

DESCRIPTION.

Polish wheat has large heads, frequently 6 or 7 inches in length and an inch or more in diameter (Fig. 1). The chaff is extremely long and rather thin and papery. The kernels are long, sometimes half an inch in length, and are very hard. In color and texture

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[1] The information given in this bulletin is based upon (1) varietal experiments conducted by the Office of Cereal Investigations, Bureau of Plant Industry, United States Department of Agriculture, and the State agricultural experiment stations, either independently or in cooperation; (2) classification studies of all American wheat varieties; (3) a survey of the wheat varieties of the United States, in cooperation with the then Bureau of Crop Estimates, based upon 19,000 returns from 70,000 questionnaires sent to crop correspondents; (4) several years of personal observation by the writer of the wheat fields in the States where these varieties are grown; and (5) milling and baking experiments conducted by the Milling-Investigations Section of the Grain Division, Bureau of Agricultural Economics, in cooperation with the Office of Cereal Investigations, and also by the State agricultural experiment stations.

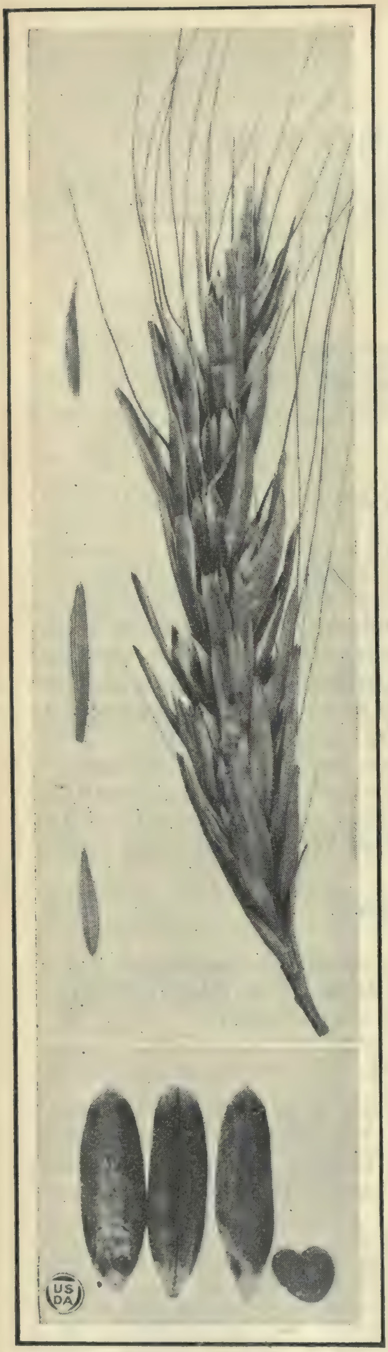

FIG. 1.—Head, chaff, and kernels of White Polish wheat. Head and chaff natural size; kernels magnified 3 diameters.

the kernels of the Polish wheat grown in this country resemble those of the amber durum wheats. In outward appearance the heads and kernels of Polish wheat are somewhat like rye, which accounts for its occasionally being sold as a variety of "giant" rye.

A number of varieties or forms of Polish wheat have been described in Europe, but only one is known to have been grown in the United States. This variety, White Polish, is grown and sold sometimes simply as Polish wheat, but more frequently under such fictitious names as Assyrian rye, Belgian rye, Corn wheat, German rye, Giant rye, Goose wheat, Jerusalem rye, Rice wheat, Siberian Cow wheat, and Wild Goose wheat. White Polish wheat has the general characteristics of Polish wheat mentioned above, viz, large, loose heads with long papery chaff and very long, hard white or amber kernels (Fig. 1). The plants are very tall, with nodding heads. The upper portions of the stems are solid or pithy. The chaff is glabrous, i. e., not velvety or hairy. The beards are black, 1½ to 6 inches long, and easily broken off at maturity. White Polish does not tiller well. It is a true spring wheat and will not survive the winter when sown in the fall except in the South or in those Pacific coast regions where the winter temperatures are mild. It is very susceptible to injury from stem and leaf rusts, and the heads are easily blasted by hot winds at flowering time.

HISTORY.

Polish wheat apparently was not grown in ancient times, but it has been known in Europe at least since 1681 and was early introduced into the United States. It was grown in Maryland as early as 1845, and many introductions of Polish wheat into this country have been made since that date. The origin of the name "Polish" is obscure, as the wheat does not appear to have been grown in Poland until many years after its discovery. The crop is now sown to a slight extent in Abyssinia, Algeria, Argentina, Italy, Spain, Turkestan, the United States, and probably other countries. It is not an important crop in any of them.

Polish wheat has been grown within recent years in California, Colorado, Idaho, Montana, Nebraska, North Dakota, Oregon, South Dakota, and probably other Western States where spring wheat is grown. The most extensive exploitations in this country have been in Idaho and Montana. Seed has been sold at such high prices as $1 a pound, or $60 a bushel, with claims for enormous yields of the wheat.

ADAPTATION.

Polish wheat can be grown wherever other spring wheats are grown, but outside of the spring-wheat regions it is almost a complete failure. Under favorable conditions it usually yields about half to three-fourths as much as the standard varieties of wheat grown in the same places. In seven years' comparative trials at Dickinson, N. Dak., White Polish wheat produced an average acre yield of less than 14 bushels, while Kubanka durum wheat yielded 24 bushels per acre under the same conditions. At Bozeman, Mont., under irrigation, White Polish wheat yielded about three-fifths as much as Marquis spring wheat. At Newell, S. Dak., in two years' comparative trials, White Polish averaged 3.7 bushels per acre and Kubanka durum 11.5 bushels per acre. These results are typical of those obtained in other spring-wheat States on both farms and experiment stations.

Polish wheat is not well adapted to any part of the United States. Where it yields well, other varieties will yield better. Only the large size of heads and kernels of Polish wheat together with the fraudulent claims of those who sell the seed have saved the wheat from going completely out of cultivation, as satisfactory yields seldom are obtained.

Polish wheat has a low gluten content and the gluten is of poor quality. Bread made from it is of poor color and texture. The same quantity of flour from a good hard spring wheat produces a loaf of bread nearly twice as large as a loaf of bread from Polish wheat flour. Macaroni manufacturers will not use Polish wheat in the manufacture of their products. The only use for Polish wheat is as stock feed, and it possesses no advantages over other more productive wheats for this purpose. It doubtless is about equal to ordinary wheat in feeding value. There is no object in growing Polish wheat other than as a curiosity.

POULARD WHEAT.

Poulard wheat usually has been considered a distinct species or subspecies, but is more closely related to our ordinary cultivated wheats than is Polish wheat. In many characters it is somewhat intermediate between common and durum wheats. Botanically, poulard wheat is known as *Triticum turgidum* or *Triticum sativum turgidum*.

DESCRIPTION.

Poulard wheat has tall, thick, pithy, or solid stems and broad leaves. The heads are long, thick, and compact and may be either branched (composite) or unbranched. Three of the four varieties of poulard wheat (Figs. 2 and 3) grown in this country have branched heads. The beards are 1 to 7 inches long and frequently break off at maturity. The chaff may be white or brown and either glabrous or velvety, depending upon the variety.

The kernels are rather short, thick, and humped. Under some conditions the kernels are hard and translucent, like durum wheats, but as usually grown the kernels are soft and chalky, due to "yellow berry." Some varieties have white (amber) and some have red kernels. The kernels are shorter but otherwise are similar to those of durum wheat and also slightly resemble those of club wheat. The simple or unbranched heads of varieties of poulard wheat are difficult to distinguish from heads of durum wheat (Fig. 3).

Both spring and winter varieties of poulard wheat are grown in this country. Poulard wheat is easily injured by rust and smut. The plants tiller poorly, so that thin stands often result from ordinary rates of seeding.

HISTORY.

Poulard wheat is reported to have been found in ruins of the ancient lake dwellings of Switzerland and in ancient Egyptian tombs. The reports may not be authentic. It appears probable, however, that this wheat was grown in Europe at the beginning of the Christian Era, and it has been definitely known for nearly 400 years. A poulard wheat, apparently identical with the Alaska variety, was brought to the United States from Ireland in 1806. It appears to have been introduced on an earlier occasion, and many samples of poulard wheat have been received in this country since that time.

Poulard wheat is not an important crop in any country, but Spain, Portugal, and Italy lead in its production. Smaller quantities are grown in Abyssinia, Algeria, Argentina, Australia, Baluchistan, Bulgaria, Canada, Chile, England, France, Germany, Greece, Siberia, South Africa, Transcaucasia, Turkestan, Turkey, and the United States. In most sections poulard wheat is grown only sparingly. In England a variety called Rivet or Cone, having an unbranched head, is the one largely grown, but even this is of minor importance in comparison with the common bread-making wheats.

The growing of poulard wheat, principally the Alaska variety, has been attempted in most parts of the United States. In recent years it has been grown and exploited chiefly in the western half of the country. It is now grown there on a very small scale as a curiosity, or by those who wish to exploit it, or by those who have recently purchased it but have not yet learned its low value.

The distribution and sale of poulard wheat in the United States have resulted almost wholly from exaggerated claims of its yield and value made by ignorant or fraudulent dealers.

ADAPTATION.

Poulard wheat is not well adapted to any part of the United States. Occasionally it produces rather high yields, but in no locality

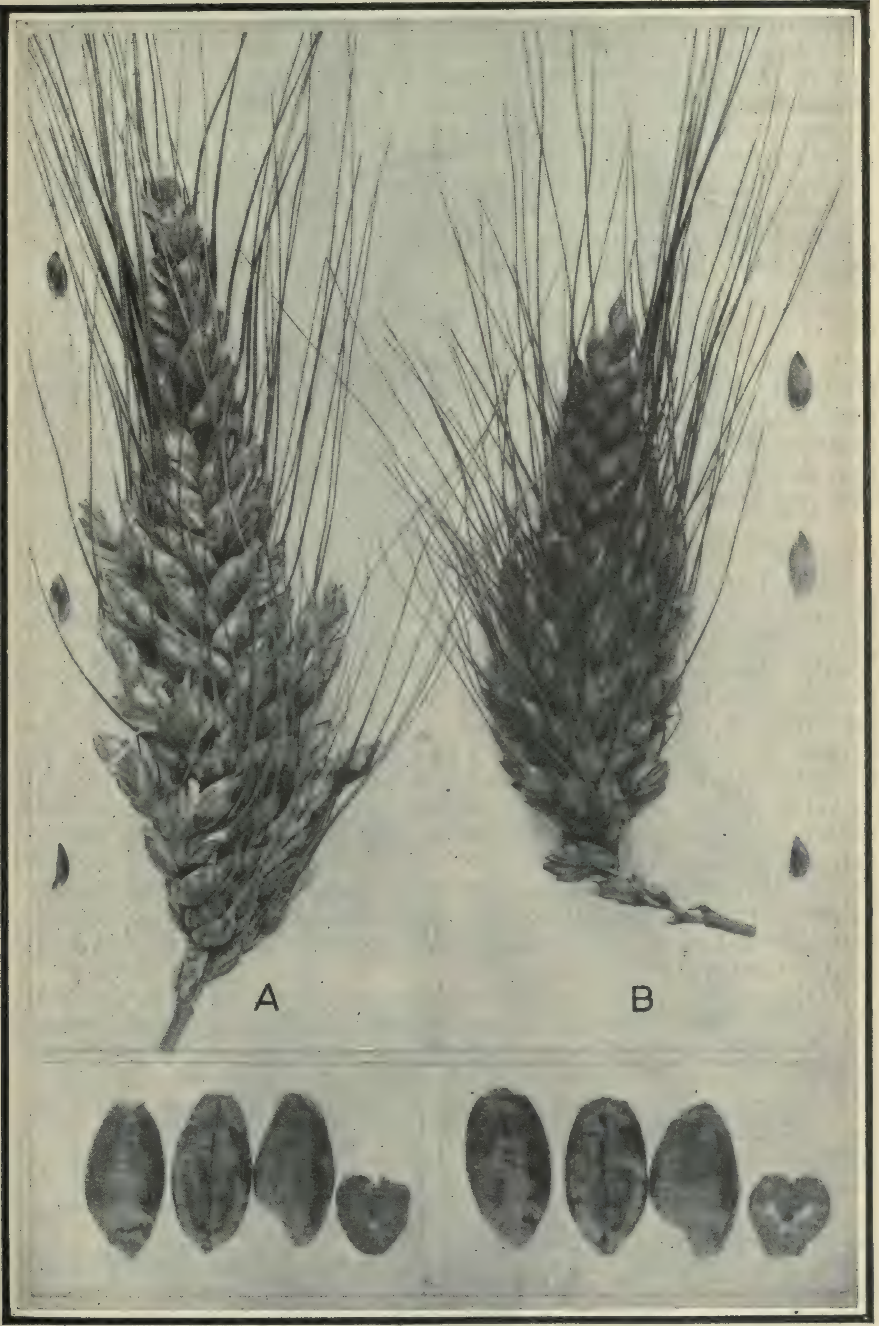

FIG. 2.—Heads, chaff, and kernels of Alaska (*A*) and Titanic (*B*) poulard wheats. Heads and chaff natural size; kernels magnified 3 diameters.

have the yields equaled those of adapted varieties of club, common, or durum wheat grown under the same conditions. Comparative yields of the varieties of poulard and other wheats are given later.

In baking quality the varieties of poulard wheat are poorer than any of the commercial wheats grown in this country, including all common, club, and durum varieties. Loaves of bread from poulard wheat usually are about half to two-thirds as large as loaves made from an equal quantity of flour of the standard varieties of wheat. Millers will not knowingly purchase poulard wheat for flour-making purposes or for making semolina to be used in macaroni manufacture. Poulard wheat is suitable only for stock feed, and as such it is not superior to other kinds of wheat.

VARIETIES.

A large number of varieties of poulard wheat have been described by European writers. Several varieties have been introduced into the United States, but only four of them are known to have been commercially grown. Of these four, which are described later, only one, Alaska, has ever been grown on a considerable scale, and even this has been limited to a few hundred acres annually.

ALASKA.

The Alaska variety has been known by all of the following names: Canadian King, Egyptian, El Dorado, Jerusalem, Many-Headed, Many-Spiked, Multiple-Headed, Miracle, Mortgage Lifter, Mummy, Reed, Russian Rhycoff, Seven-Headed, Seven-Headed Sinner, Smyrna, Syrian, Taos, Wheat of Miracle, Wheat 3,000 Years Old, and Wild Goose. Many of these names have arisen because of the branched heads of this wheat. The other names were applied by those who invented mythical stories of its origin.

Alaska wheat has large branched (composite), nodding heads with long black beards. The chaff is glabrous (not velvety or hairy) and of a yellowish color (Fig. 2, A). The kernels are white or amber and sometimes hard, although usually appearing soft and starchy because of "yellow berry." It is a spring wheat and will not survive the winters when sown in the fall, except in sections having mild winter temperatures.

Alaska wheat apparently was introduced into this country from Ireland in 1806 under the name Jerusalem.[2] In 1840 Alaska wheat grown in South Carolina was advertised in a farm journal and sold at $5 per head. At other times this wheat has been offered for sale as having been discovered in an ancient tomb or mummy case 3,000 or 4,000 years old. As wheat loses its vitality within 20 years, it is readily seen that these stories are false. On other occasions Alaska wheat (and several other kinds as well) has been claimed to have originated from a grain found in the crop of a wild goose which the advertiser or some one else had shot.

The name Alaska was applied to this wheat about 1908 by Abraham Adams, of Juliaetta, Idaho, who claimed enormous yields for the wheat and sold the seed at $20 per bushel.

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[2] For a more complete history of Alaska wheat, see United States Department of Agriculture Bulletin No. 357, Alaska and Stoner, or "Miracle," Wheats: Two Varieties Much Misrepresented.

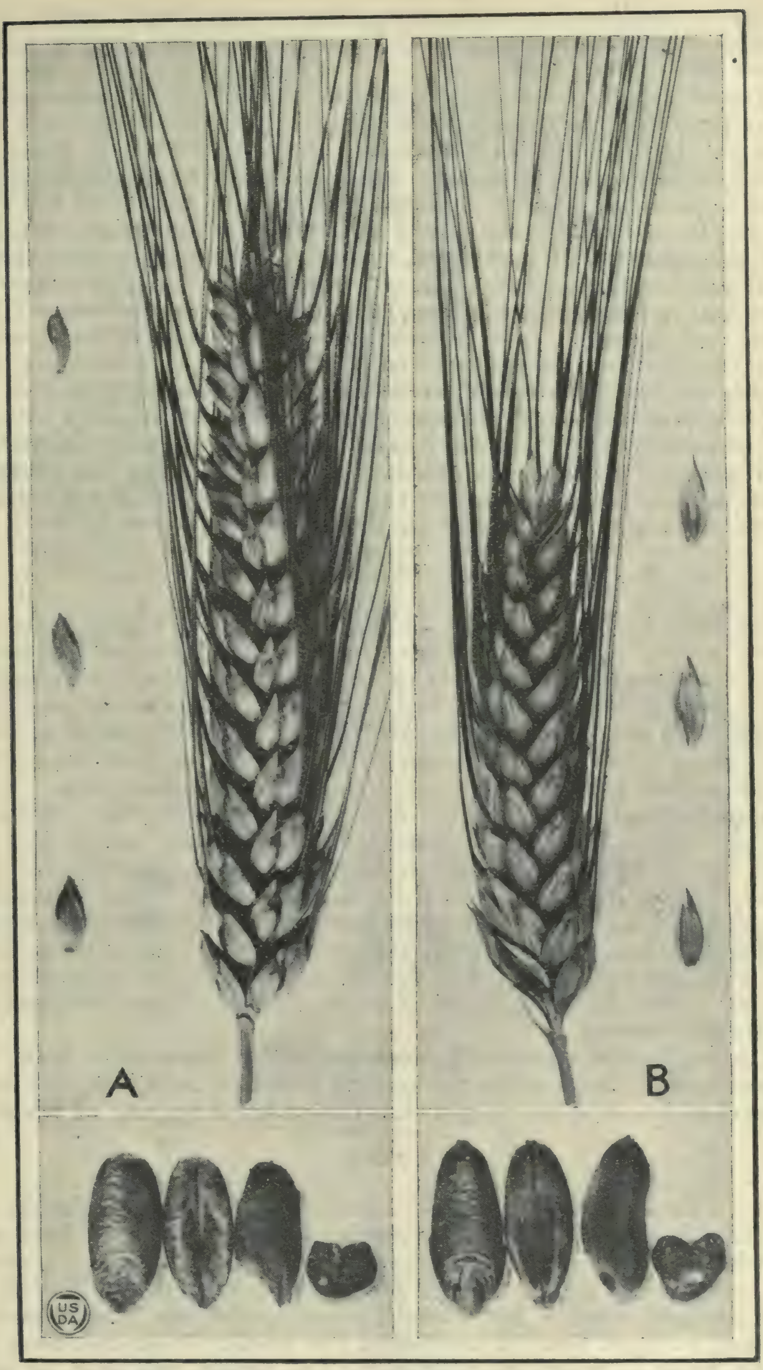

FIG. 3.—Heads, chaff, and kernels of Clackamas poulard wheat (*A*) and Peliss durum wheat (*B*). Heads and chaff natural size; kernels magnified 3 diameters.

Alaska wheat under various names has been grown in many of the Western States in recent years. Usually the wheat has been discarded after a brief trial.

In experiments covering six years at Dickinson, N. Dak., Alaska wheat produced an average yield of about 14 bushels per acre and Kubanka durum wheat 24 bushels per acre. At Newell, S. Dak., the 4-year average yield of Alaska was 9 bushels and of Kubanka 16 bushels per acre. Similar or poorer results have been obtained elsewhere. In many cases the yields have been little more or even less than the quantity of seed sown. Rarely, if ever, does the Alaska wheat yield as much as the standard varieties grown in the same districts, and in most instances the yields of Alaska are far below those of the best varieties. The branched heads of Alaska wheat contain more kernels than the unbranched heads of ordinary varieties, but as there are far fewer heads per acre the yields naturally are less.

The statements made previously in regard to the quality of poulard wheat apply fully to the Alaska variety. It is not suitable for bread-making or macaroni-making purposes. Being an inferior wheat in both yield and quality there is no logical reason for growing Alaska wheat anywhere in the United States.

WINTER ALASKA.

The Winter Alaska variety differs from Alaska wheat in having brown velvety or hairy chaff and red kernels, instead of yellowish white glabrous chaff and white or amber kernels. Winter Alaska is a true winter wheat and can not ordinarily be grown from spring sowing, like Alaska. Winter Alaska has large branched or composite heads with long black beards. It is not very hardy and can not be grown except under moderate climatic conditions.

Poulard wheat similar to Winter Alaska has long been grown in Europe. Doubtless Winter Alaska is of European origin, but the facts regarding its introduction have not been determined. The variety is now grown only on a small scale in the Puget Sound section of Washington. It produces fair yields under the mild humid conditions there, but the yields are below those of the more productive varieties grown in that district. Limited experiments with Winter Alaska have not shown it to be adapted to any other part of the United States.

Winter Alaska apparently does not differ materially from the Alaska variety in its value for making bread or macaroni, and there appears to be no object in growing this inferior variety of wheat.

TITANIC.

The Titanic variety is nearly identical with Winter Alaska, except that it has white or amber instead of red kernels. A head and kernels of Titanic wheat are shown in Figure 2, *B*. This variety was introduced into the United States in 1912 by Harry Towell, of Port Stanley, Wash. Mr. Towell, a survivor of the Titanic marine disaster, brought over 12 kernels of the wheat which had been obtained from a friend in England. The wheat was said to have been imported into England from Argentina. The Titanic variety was first grown and increased on Whidby Island in Washington. A small quantity was distributed from there in 1916, when the seed was offered for sale at $1 a pound. It is not known to be grown to any extent at the present time.

Titanic wheat has produced very low yields in comparison with standard varieties of bread-making wheats. At Chico, Calif., the 2-year average yield of Titanic was 20.8 bushels per acre, while Pacific Bluestem and White Federation, two white common varieties, yielded 28.2 bushels and 43.4 bushels per acre, respectively. Similar or poorer results with Titanic wheat have been obtained elsewhere. In bread-making value this variety is as poor as Alaska. It should not be grown in this country.

CLACKAMAS.

The Clackamas (Clackamas Wonder) variety differs from the other three varieties of poulard wheat previously discussed in having simple or unbranched heads. The heads are long, thick, and nodding (Fig. 3, *A*). The chaff is yellowish white and glabrous, with the edges bluish black and sometimes velvety or hairy. The beards are long and black. The kernels are red and are somewhat larger than those of the other poulard varieties just described. The heads of Clackamas wheat are larger but otherwise quite similar to the Peliss variety of durum wheat (Fig. 3, *B*), but Clackamas differs from Peliss in having shorter and thicker red kernels and shorter chaff and in being taller and later.

Clackamas as grown on the farms is not pure but contains several types of poulard wheat having unbranched heads as well as some mixtures of common wheat. It is a spring wheat and can not be grown from fall sowing except in districts having a mild climate.

Poulard wheats similar to Clackamas have long been grown in Europe, but it is not known when this variety was introduced into the United States. During recent years a limited acreage of it has been grown in Oregon, principally in Clackamas County, and in New Mexico.

Limited experiments with the Clackamas variety have not shown it to be of particular promise. Apparently it is not suitable for making bread or macaroni, and its cultivation could be profitably discontinued.

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U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1341

MULE PRODUCTION

THE ABILITY of the mule to endure hardship and perform sterling service under adverse conditions has established him as a real asset in American agriculture.

The mule will give best service under favorable conditions of feeding and management.

Good, sound mares should be selected for breeding in order to be successful in producing high-grade mules. A very desirable "mule mare" is one having about one-fourth draft blood.

The most practical feeds to use for mules are those which are grown on the farm or plantation so far as they provide the essential nutrients for a balanced ration.

The general form and appearance of the mule should resemble closely that of a horse, and in judging mules the same general points of perfection should be looked for.

Mules vary in height from 12 hands to 17½ hands and in weight from 600 pounds to 1,600 pounds.

While the mule is essentially a draft animal, it is used widely for utility purposes, especially in the South. A smart, alert mule, with a long, free stride at the walk and a snappy, balanced trot is highly desired.

Washington, D. C. August, 1923

MULE PRODUCTION.[1]

By J. O. Williams, *Senior Animal Husbandman, Animal Husbanary Division, Bureau of Animal Industry.*

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DISTRIBUTION OF MULES IN THE UNITED STATES.

THE importance and popularity of the mule as a work animal is attested by the greatly increased use of the animal in our farm operations. In 1910, the number of mules on farms and ranches was 4,209,769. The number on January 1, 1920, was 5,432,391, an increase, during the decade, of 1,222,622, or nearly 30 per cent. Of the 5,432,391 mules on farms in 1920, 3,172,797, or nearly three-fifths, are in the nine Cotton Belt States, which in the number of mules rank as follows:

Texas	845, 932
Georgia	406, 851
Oklahoma	336, 635
Arkansas	322, 677
Mississippi	308, 216
Alabama	296, 138
North Carolina	256, 569
South Carolina	220, 164
Louisiana	180, 115
Total	3, 172, 797

The only States outside the Cotton Belt having more than 175,000 head of mules are Missouri, with 389,045, Tennessee 352,510, Kansas 243,332, and Kentucky 292,857. The total number of horses in the Cotton Belt States on January 1, 1920, was 2,855,257, or about 90 per cent as many horses as mules. The only Cotton Belt States having more horses than mules are Texas and Oklahoma.

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[1] In the preparation of this bulletin the writer is indebted for helpful suggestions and assistance from G. A. Bell, horse-breeding expert in the Remount Service, War Department, and R. S. Whitfield, a former employee of the Animal Husbandry Division.

ADVANTAGES OF THE MULE AS A WORK ANIMAL.

The mule is a hardy work animal. While this humble creature responds to good treatment and gives best service under favorable conditions of feeding and management, it is his ability to endure hardship and to perform sterling service under adverse conditions that has established him so firmly in American agriculture. Those who are stanch supporters of the mule say that, in comparison with the horse, he will live longer, endure more work and hardship, require less attention and feed, is less liable to digestive disorders, lameness, and disease, is more easily handled in large numbers, is less irritable, and is more capable of performing work in the hands of a mediocre or poor horseman. Whether or not all these claims may be substantiated, it is a fact that the mule is well established as a work animal in those sections where climatic conditions are most severe, feed less abundant, and horsemanship is not a prevailing art (Fig. 1).

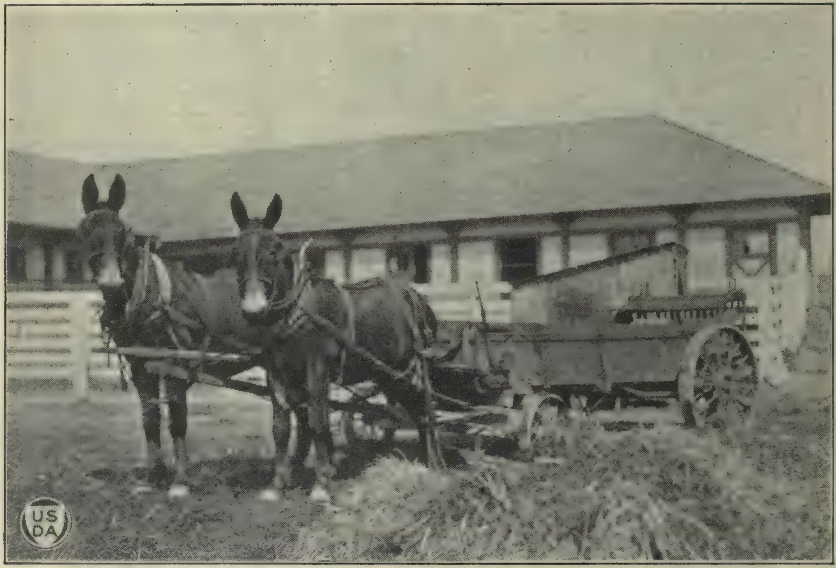

FIG. 1.—A pair of farm mules.

SOME PECULIARITIES OF THE MULE.

The mule is an animal with possibly more eccentricities and undeniable virtues than any other domestic animal. One would naturally expect from his heritage a rather unusual temperament requiring the most thoughtful treatment. The difficulty is to know how to handle the mule in order to keep the desirable qualities of his maternal ancestry in the foreground and to keep subservient the latent donkey characteristics. To treat consistently a conglomeration of stubbornness and willingness, temper and sullenness, contentment and restlessness, slyness and docility, faithfulness and waywardness, with no knowledge of which virtue or vice is going to assert itself next, is a problem which may well tax the qualities of the best horseman. Yet the virtues of the mule have been so evident in times of peace and war that many ardent horse lovers who have been prejudiced against him have come to admire the animal which has no "pride of ancestry or hope of posterity" (Fig. 2).

There are some peculiarities which belong to the mule alone. He does not like to be hurried, worried, or cuffed about; to try to force him to do things against his will is practically impossible and only makes matters worse. The mule must be understood and gently but firmly persuaded to do things out of the ordinary. He is naturally suspicious of everybody who comes around him, and it can be readily observed that he never takes his eye off a person near by, and when the ears begin to wag a little the person watched had better be on the lookout. There seems to be a code system of ear signaling among mules that they all understand. A mean mule can deftly handle his hind legs, and his forelegs are not to be ignored. He has been known to handle his "mits" in a clever fashion. The mule seems to have an uncanny way of detecting whether a person is going to treat him harshly or kindly, and his reception is usually in like manner, nor does he forget the person who inflicts harsh treatment.

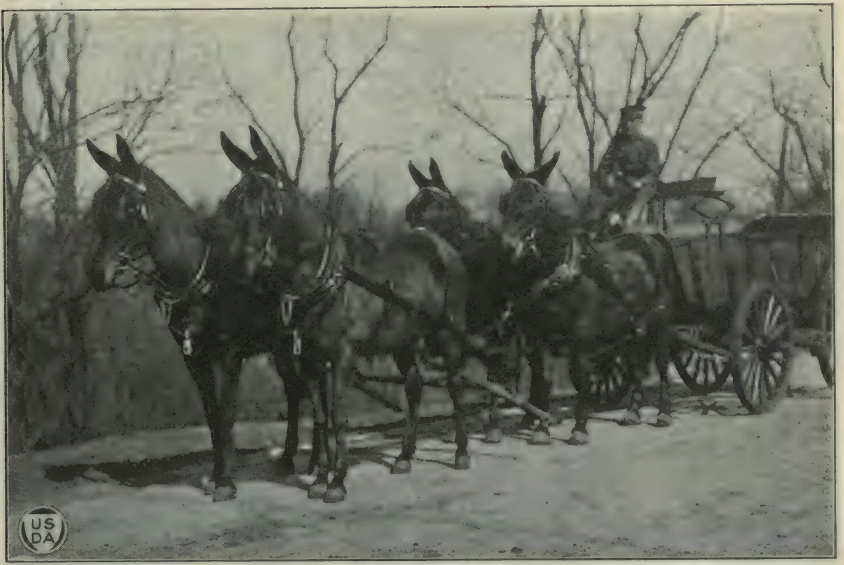

FIG. 2.—Many mules find their way into the U. S. Army. Good, sound mules with quality are required. This illustration shows representative types of "lead" and "wheel" mules in Army service.

There is a wrong and a right way to lead a mule. A man who looks at a mule and lugs at his head will never make any progress. The mule will not be pulled. He will usually follow quietly, however, if a man will walk away in the direction he desires to go. Neither can you "bully" mules into going through tight places; they are somewhat like sheep, and if the leader can be induced to go the rest will follow.

Next to satisfying a hearty appetite the height of mule joy is to roll. A mule will roll at every opportunity and often at inopportune times, when he makes the opportunity suit his own convenience. He dislikes mud and water holes in the road. and is what is known as a sure-footed animal.

PRODUCTION OF MULES.

The mule is a hybrid animal having a jackass, commonly called a jack, for a sire and a mare for a dam. When the reverse cross is made and the female ass (or jennet) is bred to a stallion, the offspring is called a "hinny." As the mule will not reproduce, it is necessary to maintain both jacks and mares in order to produce mules.

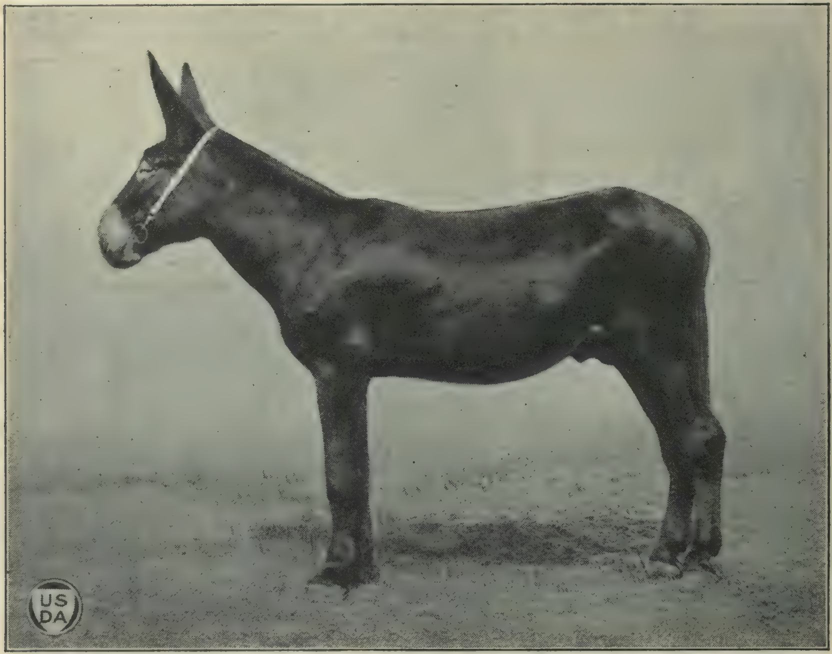

FIG. 3.—A prize-winning jack. Note size of bone and general quality throughout.

SELECTING THE JACK.

The importation of jacks, and consequently the production of mules, dates back to colonial times. About 1787 George Washington was presented with a jack by the King of Spain, which was used in the stud at Mount Vernon. Many good mules were produced in those days, and the value of the mule as a work animal was soon recognized by intelligent planters. It has been within the last 40 years, however, that the production of mules has been an extensive enterprise and that much attention has been given to the rearing and selection of the best jack stock.

The American jack of to-day is a composite of the bloods of some of the best foreign breeds, and in attaining the highest standard of excellence prevailing in the jack stock of America the breeders have emphasized the valuable utility points so much desired in the best jacks, such as size, weight, bone, style, quality, and action. In America jacks are usually spoken of as jennet jacks and mule jacks. As these terms imply, jennet jacks are used for mating with jennets for the reproduction of the breed, and mule jacks are used for mating with mares for the production of mules.

A good mule jack (Fig. 3) should be not less than 15 hands high and possess plenty of weight, large bone with quality, style, and action. The essential points of conformation in a good jack are a straight, strong back, closely coupled and well muscled over the loin; long and level rump; deep body and spring of rib to allow ample room for lung development. Vigor and strength of constitution are indicated by a broad chest and large heart girth.

The legs should be set straight, be well muscled, and have plenty of bone. The length of leg should be in proportion to depth of body, as height obtained by length of leg is undesirable. The size of the bone is very important and should be ample. The size of the bone is usually determined by measuring the cannon bone about half-way between the knee and the fetlock joint. This circumference should be 8½ inches in a jack of 15 hands' height. It is very desirable to have large, well-shaped feet. The head should be well proportioned, with the profile of the nose straight or slightly roman. The ears should be long, well set, and alert on a mature animal and should measure, horizontally, 33 inches or more in length from tip to tip.

Measurements of a good jack.[1]

[Weight, 1,200 pounds; height (standard measure), 15 hands, 3 inches.]

	Inches.		Inches.
Ears from tip to tip	34	Around body at girth	70
Around face and jaw	39	Around body at loin	67
Around neck at throatlatch	36	Around hoof, below coronet (next to hair)	16½
Around arm	21	Above hock	17½
Around cannon	8½	Below hock	9½
Length from poll to tail	84		

Some of the common defects in jacks which should be avoided are: Flat, narrow chest, which indicates a weak constitution and lack of vigor; light-muscled loin and long coupling; short, drooping rump; excessive length of leg; small feet with contracted heels; and short or droopy ears.

CARE OF THE JACK.

The proper care and management of the jack are somewhat exacting, as he is rather peculiar in his likes and dislikes. While a stallion may be spoiled because of his nervous temperament, the jack may be just as quickly spoiled because of his inclination to be sluggish. The jack should have a caretaker who understands jack management thoroughly. This is very important, as the disposition of the jack is partly controlled by the groom. The jack should be quietly but firmly handled, as a bad disposition in a jack is usually attributable to harsh handling or mismanagement of the animal when young. Through continuous observation the groom should learn the peculiar individuality of the jack and the little things required for his proper management.

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[1] Twice champion at the Missouri State Fair and reserve champion at the World's Fair, San Francisco.

Abundant exercise is one of the big factors in the management of a breeding animal. A roomy, well-ventilated, and well-lighted box stall opening to an exercising paddock is necessary for the proper care of the jack. It is important that the exercising paddock be of good size. In order to insure plenty of exercise, however, it is well to give the jack some road work.

A young jack intended for siring mules should not be permitted to run with jennets or mules, as this practice usually leads to difficulty in teaching him to serve mares, when used in the stud. Instead the young jack should have fillies or gentle mares for companions. The jack may begin serving mares at the age of 2 or 2½ years, but he should not serve more than one mare a day during his first season nor more than 30 for the entire season. A mature jack may serve as many as two mares in a single day provided the two services are several hours apart. The number of mares a jack should serve during a season depends on the strength and vigor of the individual, but 70 or 80 mares probably is the maximum number that he can serve with satisfactory results. Artificial breeding may be employed if the jack is patronized very heavily. This not only conserves the vitality of the jack but also enables the owner to breed a much larger number of mares. If care and precaution are taken, artificial breeding may be practiced with as much success as breeding in the natural way. In fact, some mares which do not conceive from natural service are successfully impregnated artificially. It is sometimes advisable to use a stallion for teasing purposes in order to conserve the jack when the patronage is heavy.

FEEDS FOR THE JACK.

The jack is a rather sluggish animal, and for this reason his feeds should be slightly laxative in character. Bran, oats, crushed barley, and oil meal are splendid grain feeds to use. Sheaf oats and green feeds are also very satisfactory. Corn should be used only in limited amounts. Many jack breeders obtain good results by feeding sheaf oats, clover, and alfalfa hay.

THE BROOD MARE.

Sound brood mares of good quality should be selected in order to be successful in producing high-grade mules. Considerable effort is usually expended by the breeders of work horses in selecting good mares for breeding purposes, but no consistent effort is usually made by the mule breeder in exercising the same care in selecting brood mares for the production of mules. The idea seems to prevail that

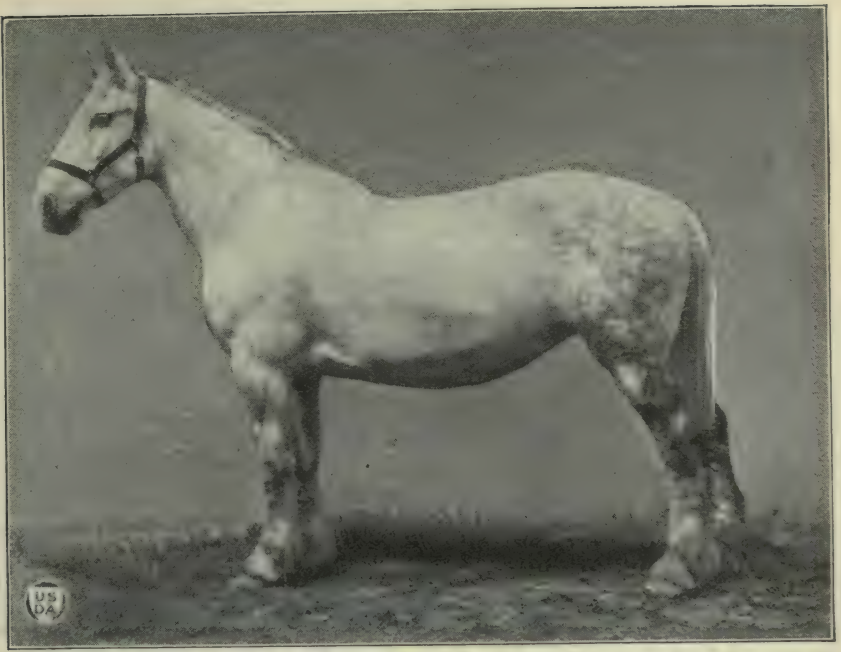

FIG. 4.—A desirable type of brood mare for producing draft mules. Note the "breediness," substance, and conformation of this mare.

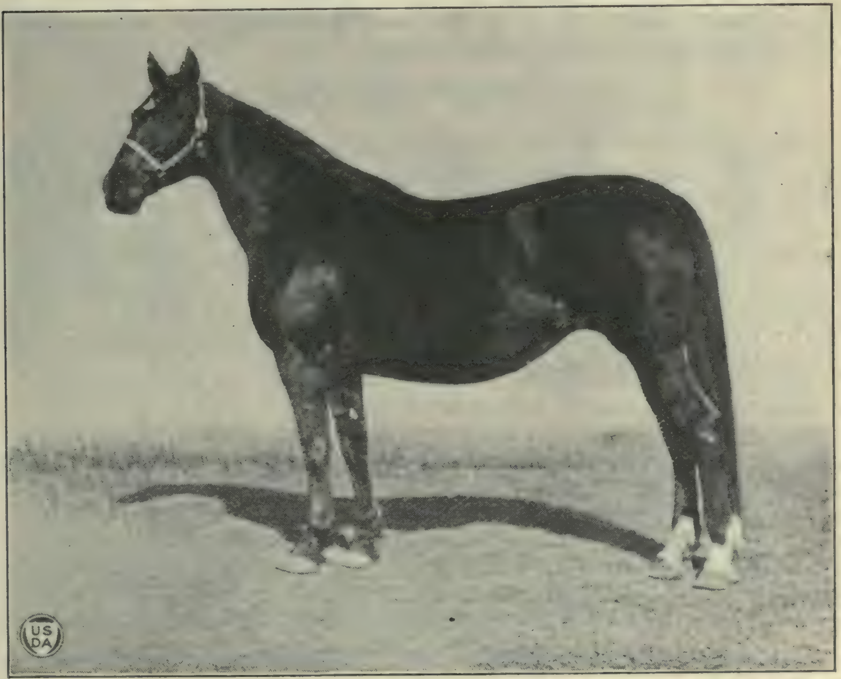

FIG. 5.—A desirable type of light "mule mare" for producing mules of quality. Note roominess of body, short back, depth of heart girth, and "breediness" of this mare.

a mare which is not suitable for breeding to a stallion is good enough to produce a mule. This is a mistake, for no matter how good the jack may be, it is inconsistent to expect uniformly good mule colts from inferior mares. The same care should be applied in selecting mule mares as is exercised in selecting brood mares to raise horse colts. The mares used in mule production are of no fixed type or breed and vary from the large, heavy mares of the draft breeds to the smaller mares of the light-horse breeds (Figs. 4 and 5). As the mule is a work animal which can not reproduce its kind, it is not essential that mares for producing them be of any fixed breeding. Mules from the larger mares of the draft breeds are large and heavy and are excellent for draft purposes, but they are more sluggish and can not stand heat so well as mules produced from mares having light-horse blood in their veins. Experienced breeders state that a very desirable mule mare is one having about one-fourth draft blood. A mare of this breeding will produce good-sized mules, with style, action, and stamina. It seems that type rather than breeding is the prime requisite of a good mule mare.

In conformation the mule mare should possess all the good qualities desired in the brood mare used for producing good work horses. Some of the most important points of the good mule mare are:

A broad chest and large heart girth, indicating a vigorous constitution; a roomy barrel to allow for full development of the fetus; a straight back, strongly muscled over the loins; well-set legs with broad, flat bone, sound and of good quality; large and well-shaped feet; and feminine character, indicating "breediness." To sum up, the mare should combine size with quality, type, soundness, and breediness. The last term includes a variety of characteristics which makes the mare a good mother.

BREEDING THE MARE.

The mare will come in heat, on an average, every 18 to 21 days and will remain in heat from 2 to 4 days, though exceptional mares vary in this respect and remain in heat only a few hours. The mare usually comes in heat on the ninth day after the foal is dropped. In order to avoid accidents at breeding time, hobbles should always be put on the mare. Conception is more likely to take place if the mare is rested for a few hours at time of service. The mare should be returned to the jack in from 18 to 21 days after service, in order to make sure that conception has taken place.

Table 1.—*Calendar showing time of service and date of foaling based on 340-day gestation period for mares.*

Day of month mare is bred.	Date of foaling.											
	Bred in Jan.	Bred in Feb.	Bred in Mar.	Bred in Apr.	Bred in May.	Bred in June.	Bred in July.	Bred in Aug.	Bred in Sept.	Bred in Oct.	Bred in Nov.	Bred in Dec.
	Dec.	*Jan.*	*Feb.*	*Mar.*	*Apr.*	*May.*	*June.*	*July.*	*Aug.*	*Sept.*	*Oct.*	*Nov.*
1	6	6	3	6	5	6	5	6	6	5	6	5
2	7	7	4	7	6	7	6	7	7	6	7	6
3	8	8	5	8	7	8	7	8	8	7	8	7
4	9	9	6	9	8	9	8	9	9	8	9	8
5	10	10	7	10	9	10	9	10	10	9	10	9
6	11	11	8	11	10	11	10	11	11	10	11	10
7	12	12	9	12	11	12	11	12	12	11	12	11
8	13	13	10	13	12	13	12	13	13	12	13	12
9	14	14	11	14	13	14	13	14	14	13	14	13
10	15	15	12	15	14	15	14	15	15	14	15	14
11	16	16	13	16	15	16	15	16	16	15	16	15
12	17	17	14	17	16	17	16	17	17	16	17	16
13	18	18	15	18	17	18	17	18	18	17	18	17
14	19	19	16	19	18	19	18	19	19	18	19	18
15	20	20	17	20	19	20	19	20	20	19	20	19
16	21	21	18	21	20	21	20	21	21	20	21	20
17	22	22	19	22	21	22	21	22	22	21	22	21
18	23	23	20	23	22	23	22	23	23	22	23	22
19	24	24	21	24	23	24	23	24	24	23	24	23
20	25	25	22	25	24	25	24	25	25	24	25	24
21	26	26	23	26	25	26	25	26	26	25	26	25
22	27	27	24	27	26	27	26	27	27	26	27	26
23	28	28	25	28	27	28	27	28	28	27	28	27
24	29	29	26	29	28	29	28	29	29	28	29	28
25	30	30	27	30	29	30	29	30	30	29	30	29
26	31	31	28	31	30	31	30	31	31	30	31	30
	Jan.	*Feb.*	*Mar.*	*Apr.*	*May.*	*June.*	*July.*	*Aug.*	*Sept.*	*Oct.*	*Nov.*	*Dec.*
27	1	1	1	1	1	1	1	1	1	1	1	1
28	2	2	2	2	2	2	2	2	2	2	2	2
29	3	......	3	3	3	3	3	3	3	3	3	3
30	4	......	4	4	4	4	4	4	4	4	4	4
31	5	......	5	......	5	......	5	5	......	5	......	5

CARE OF THE PREGNANT MARE.

There should be no sudden changes in feed or work of the mare after she becomes pregnant. She should be given a well-balanced ration of feed that will supply the needs of her own body as well as those of the growing fetus. Feeds that are too fattening should be avoided, also moldy or damaged hay, as there is a suspicion that either may cause abortion. Exercise is a most important essential to the health of the pregnant mare, as well as for the development of a strong, healthy foal. The best and most economical way of giving this exercise is by using the mare in regular farm work. The pregnant brood mare should not be subjected to hard pulls or severe strains. By using care and judgment the mare may be safely worked up to within a week or ten days of foaling. The average gestation period of mares—that is, the length of time that they carry their foals—is about 340 days. This period varies slightly with individual mares. It is important that a careful record be kept of the date of service to the jack in order that the time of foaling may be anticipated. A very sure sign that the foal will be dropped in a short while is the appearance of wax on the teats, which usually appears two or three days before parturition.

CARE OF MARE AT FOALING TIME.

About a week or ten days before the foal is expected the mare should be turned into a pasture or paddock, where there is no danger of injury from other animals. If the weather is mild, a paddock or pasture is a desirable place for the foal to be delivered. There is probably less danger of infection in a pasture than in a stable. If desirable conditions for foaling outside can not be provided for, a roomy box stall that has been well cleaned out, disinfected, and bedded with fresh straw should be provided.

It is well to observe the mare closely when the foal is expected, in order that assistance may be given in delivery if necessary. It will be necessary for the attendant to be where he can see the mare and yet be unseen by her. Should she need assistance, a veterinarian should be summoned at once. If it is essential that aid be given, the service should be rendered by one who has had experience with and understands the many phases of difficult parturition.

If the foal has been delivered satisfactorily, the attendant should remove as soon as possible any tissue or matter that may be clogging its nostrils and see that respiration is started. Assistance may be rendered in this respect by blowing into the foal's nostrils and rubbing its sides with a cloth or wisp of straw. As soon as practicable, without disturbing the mare unnecessarily, remove the afterbirth from the proximity of the mare and, if foaling occurred in a stable, clean out the bedding that has been soiled during parturition, sprinkle lime on the floor where the bedding has been removed. and supply fresh bedding.

To prevent infection, the navel cord of the foal should be saturated with full-strength tincture of iodin or a solution of 1 to 1,000 corrosive sublimate, and then dusted with powdered slaked lime. This should be repeated each day until the navel cord drops off. A normal foal will usually find its own way to the mare's udder soon after arrival. If, however, the foal is weak and unable to stand within two or three hours after birth, it should be assisted in getting its first meal. It is very important that the newborn foal get the first milk from its dam, which is a substance called colostrum. In addition to having the food properties so much needed by the new born, the colostrum also has a purgative effect, which stimulates the action of the digestive tract in eliminating the fecal matter already collected during the period of gestation. If this fecal matter is not eliminated within 24 hours after the colt is born, a dose of castor oil (2 to 4 tablespoons) shaken well in milk should be given and repeated in three or four hours until the desired results are obtained.

CARE OF MARE AND FOAL.

The mare should receive bran mashes and light feeds until she has recovered from the effects of foaling and the feverish condition of her system has disappeared. The ration should then be increased gradually until the mare is on full feed.

When the weather is warm and pleasant, the mare and foal may be turned out on pasture or paddock as soon as the foal is able to follow, as exercise is very beneficial and they will thrive better in the open.

If the mare was being worked prior to foaling, she will be ready for work again in 10 days or two weeks after the colt is born. When this is done the colt should be confined in a stable or paddock and not permitted to follow in the fields. The mare and colt will fret for each other for a while, but they will soon become accustomed to separation. When working, the mare should be returned to the stable once in the forenoon and in the midafternoon to allow the colt to suckle. The mare should be allowed to cool before being turned in with the colt, as there is danger of causing the colt to have scours and other digestive troubles if the mare is overheated when nursing.

When the mare is idle during the fly season, it is best to keep her and her foal in a darkened stable in the day and turn them out on pasture at night. The mare should be fed some grain and hay, as grass alone will not supply the needs of her body and also provide a sufficient milk flow for the colt.

The colt usually begins to eat a small amount of grain at the age of three or four weeks. Oatmeal should be the first grain fed and bran may be added later. Best results in feeding grain to colts in the open are obtained by building a creep under which they may pass at all times and which will prevent the mares or other mature horses from reaching the feed provided for the colts. The colt will eat only a little grain at first, but it is worth much to have it begin eating a small amount as soon as possible, because the more accustomed it becomes to eating grain while young the less trouble there will be at weaning time. The mare may be induced to frequent the creep by giving her an occasional feed near there also.

WEANING THE COLT.

Under ordinary conditions the colt is usually weaned when about six months old, but if the mare is working and the colt is thrifty it may be weaned earlier. When the colt has been taught to eat grain early, this separation from its dam need not cause any check in the colt's development. This is a trying time in the life of a colt, however, and it should receive additional feed and care to make up for the loss of the mother's milk from its ration. When the colt is once taken away from the mare, the separation should be made complete.

The mare requires some individual attention at weaning time. It will be necessary to milk her by hand for a few days to prevent too much milk from collecting in the udder and causing it to become caked and swollen. To assist in the drying-up process, the mare should be milked only partially dry and if the milk flow is maintained the grain ration should be reduced for a few days.

CARE OF THE COLT AFTER WEANING.

At no time in the colt's life is pasture more important than at the time of weaning. On being taken away from its dam, the colt needs succulent feed and the best way of supplying this feed is by having a good pasture. Not only is a good pasture necessary for the development of the colt, but it is also necessary if the colt is to be raised in an economical manner. In addition to the pasture the colt should receive liberal amounts of grain and hay. Half of its growth is made during its first year and it should have every advantage possible for its development. Colts like companionship and they do better if several are allowed to run together (Fig. 6).

THE ORPHAN COLT.

It may happen sometimes that the mare dies soon after foaling or fails to give milk enough for her foal. When either of these misfortunes occurs the colt must be raised by hand, which is a tedious undertaking but is worth while if done properly. As a feed for the orphan colt, the best and most practical substitute for mare's milk is cow's milk after it has been prepared to conform as nearly as possible in composition to the milk of the mare. This is done by selecting milk that is low in butterfat and diluting it with one part of fresh water for three parts of milk. Add a tablespoon of sugar and three or four tablespoons of limewater to a pint of this diluted milk and heat to body temperature. Give the foal about a half teacup of this prepared milk at first and at short intervals gradually increase the amount and the length of time between feeding periods as the foal develops. A bottle with a rubber nipple attached is the most convenient way to give milk to the orphan. As the foal suckles frequently in small amounts when following its dam, one should feed it frequently and thus conform as nearly to natural conditions as possible.

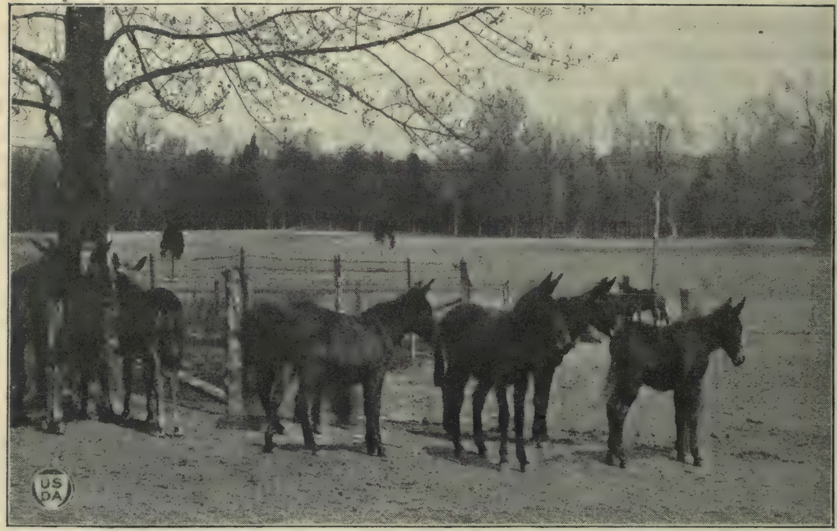

FIG. 6.—Mule foals like companionship. A group of weanlings on pasture.

The utensils used in feeding the orphan foal should be kept scrupulously clean. This can be done by freely utilizing hot water and sunshine, both of which are enemies to germs that collect and thrive in milk containers.

SPRING OR FALL COLTS.

The climatic conditions and nature of the farm work determine largely whether it is best to have the colts come in the spring or in the fall.

The natural breeding season for mares is in the spring, which is the generally accepted time to have colts. There are, however, several advantages of having fall colts, especially in the South. The fall-born colt comes at a time when the mare can probably be more easily spared from farm work and at a time when flies are not so abundant. Another advantage is that the fall colt is weaned at a time when it can be turned on to pasture and its development is not retarded at this critical time. The spring colt is weaned at a time when the grazing season is practically over.

EDUCATING THE COLT.

The time to begin the education of the colt is early in its life. It should be halterbroken and taught to be led when a few weeks old. The more the colt is handled when young the fewer difficulties will be encountered later when it is desired to put him to work.

Mules reach maturity at the age of 5 years, but they may be given light work when 3 years old. Care should be taken not to overload young mules. Overtaxing the young animal not only tends to check its development but also causes it to become unreliable as a worker, and possibly balky. A young mule that becomes accustomed to moving a load every time it is called upon will develop into a reliable work animal.

FEEDING AND CARE OF MULES.

Too little thought and attention are usually given to the proper methods of management and feeding of mules. Where the use of mules as work stock prevails, the feeding is usually done in a haphazard manner without regard to efficiency and economy. The essentials of a good caretaker are judgment and common sense combined with some knowledge of feeds. The most practical feeds to use are those which are grown on the farm or plantation so far as they provide the essential nutrients for a balanced ration. Corn, oats, and barley are the most widely used grains, as there is hardly a section of the United States where one or more of these grains are not grown. These grains may be combined to make a satisfactory feed or taken singly and supplemented with such feeds as bran, oil meal, or cottonseed meal to make a balanced ration. A balanced ration is one which will supply the protein and carbohydrate elements in such proportion as to meet as nearly as possible the body requirements of the animal for doing the work which it is to perform.[2] The same principles that are used in the correct feeding of horses may also be applied to the feeding of mules. As a general rule 1.1 pounds of grain and 1¼ pounds of hay daily per 100 pounds of live weight will be found to be about the right amount of feed to use for an animal at medium work. The exact quantity of feed depends upon the individual animal and must be determined by the feeder.

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[2] Methods of computing a balanced ration are fully explained in Farmers' Bulletin 1030, Feeding Horses, which may be obtained on request from the Division of Publications, Department of Agriculture, Washington, D. C.

While there are many cases in which mules are underfed, there are probably many others in which the owner suffers financially because the mules are fed more high-priced feeds than they really need, through the use of improperly balanced rations. Overfeeding is most likely to be done during the winter months, when the mules are idle. During this period idle mules may be kept in good condition largely on hay and straw and a small amount of grain. Mules that are worked hard and are receiving heavy rations should have their feed allowance diminished when idle. Idle mules thrive better if they are not confined in stables but are kept in the open.

Digestive disorders are more prevalent among work stock during the spring and summer months than at any other time. This is due to the improper feeding and watering of overheated animals. If the work animal appears to be excessively warm when brought in from work, it should be permitted to cool off before watering or feeding. Attention to such details will prevent many cases of colic. Mules sometimes suffer in hot weather from heat because they are allowed to eat too much grain or hay. This is most likely to occur when fresh, new hay is being fed. The hay ration should be fed mainly at night so that there will be several hours in which the mule may partly digest and assimilate this bulky feed before going to work.

Mules like to roll after being unharnessed, and they should have a place where they may rest themselves in this way. They will be much more comfortable in summer if they are turned out of their stables at night after they have cleaned up their feed. If they are turned on to pasture at night they will sweat more the next day, but the beneficial effects obtained from the grass and being in the open will more than offset the effects of excessive sweating. If unable to provide pasture for the mules at night during the summer, a paddock or lot should be provided where they may be comfortable.

JUDGING MULES.

The general form and appearance of the mule should resemble closely that of a horse, and in judging mules the same general points of perfection are looked for. The nearer the mule approaches the ideal desired in a draft horse the more valuable he is from a market standpoint. In the mule there are certain characteristics derived from his paternal side which are mainly indicated in his bray, disposition, ears, tail, and feet, aside from which the mule does not differ materially from the dam.

Mules vary in height from the little 12-hand pit mules to the large draft mules standing 17½ hands. The range in height of various classes of mules is given in another portion of this bulletin under "Market classes of mules."

The weight of mules varies from 600 pounds to 1,600 pounds. The average weight of the larger type of mules varies between 1,150 and 1,400 pounds and is the range of weight within which the majority of the most marketable mules are classified.

The form of the mule should be compact, with a deep body, broad chest, full flanks, short back, and well-sprung ribs. Light, waspy flanks, long narrow bodies, and long backs are not desirable.

Quality is rather difficult to define, but is that which every capable judge looks for in any animal. It is indicated in a mule by a trim, fine ear, clean-cut head and joints, flinty flat bone, well-defined tendons, and soft, silky hair. Quality marks the difference between a "market topper" and a "jar head." A short, thick ear, a coarse head, round, spongy bone, and a harsh coat of hair are indications which the judge should discriminate against.

The natural tendency of the mule is to be lazy and obstinate. An active, energetic mule is much desired.

It is in the hind quarters of the mule that the greatest faults of conformation are usually found. The croup is often very short and steep, the hips sloping, the thighs narrow, and the hind legs sickle shaped. These are faults of conformation that judges should discriminate against sharply. It is in the hind quarters and loins that the draft animal obtains propelling power. These portions of the animal, therefore, should be correctly built and properly developed. The loins should be broad, short, and thickly muscled; the croup long and level; the hips long, level, and muscular; the thighs thick,

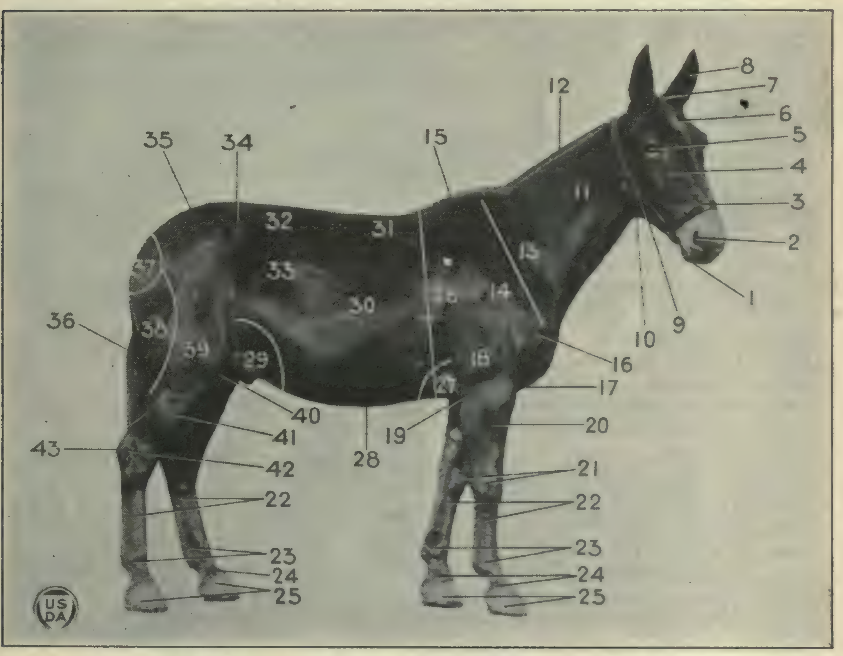

FIG. 7.—The points of the mule: 1, mouth; 2, nostril; 3, nose; 4, face; 5, eye; 6, forehead; 7, poll; 8, ear; 9, throatlatch; 10, neck; 11, crest; 12, shoulder bed; 13, shoulder; 14, withers; 15, point of shoulder; 16, breast; 17, arm; 18, elbow; 19, forearm; 20, knees; 21, cannons; 22, fetlocks; 23 pasterns; 24, feet; 25, heart girth; 26, fore flank; 27, underline; 28, hind flank; 29, barrel; 30, back; 31, loin; 32, coupling; 33, point of hip; 34, hip; 35, croup; 36, tail head; 37, buttock; 38, thigh; 39, quarters; 40, tail; 41, stifle; 42, gaskin; 43, hock.

long, and well muscled; and the hind legs well set, with broad, clean-cut hocks and flat, dense bone. The mule should stand on good feet that are well shaped.

While the mule is essentially a draft animal, it is used widely for general utility purposes, especially in the South. Though style and action may not be so important qualities in a mule as they are in the lighter breeds of horses, these qualities add materially to its value. A smart, alert mule, with a long, free stride at the walk and a snappy, balanced trot is highly desired. Figure 7 and the accompanying score card give points in the study of conformation.

Score Card for the Mule.

Scale of points.	Standard score.	Points given animal judged.	
		Student's score.	Corrected score.
GENERAL APPEARANCE—16 points:			
Height—Estimated hands....; actual hands.....			
Weight—Estimated....; actual....; according to age and type	4		
Form—Broad, deep, compact, smooth, symmetrical	4		
Quality—Clean, dense bone with sufficient substance; refined head and ears; fine hair; defined joints and tendons	4		
Temperament—Active; good disposition	4		
HEAD AND NECK—7 points:			
Head—Proportionate; clear-cut features	1		
Forehead—Broad, full	1		
Eyes—Full, bright, clear	1		
Muzzle—Broad, fine; large nostrils; trim and even lips	1		
Ears—Large, long, pointed, fine, well set, carried alert	1		
Neck—Long, muscular, clean-cut throatlatch	2		
FOREHAND—24 points:			
Shoulders—Long, sloping, smooth, muscular, blending into smooth, well-defined withers	3		
Arms—Short, muscular, elbow in	1		
Forearms—Long, wide, muscular	2		
Knees—Straight, wide, deep, well supported	2		
Cannons—Short, wide, flat, well-defined tendons	2		
Fetlocks—Wide, straight, tendons well back, well supported	1		
Pasterns—Of medium length, oblique (about 45°), clean, strong	3		
Feet—Of medium size, set straight; dense, smooth horn; slope of wall parallel to pastern; wide, high heels; concave sole; strong bars; prominent, elastic frog	6		
Leg position—In front, a perpendicular line from point of shoulder should divide the leg and foot into lateral halves; from the side, a similar line from the bony prominence on shoulder blade should pass through the center of elbow, knee, and pastern joints, and meet the ground back of foot	4		
BODY—9 points:			
Chest—Deep, wide	2		
Ribs—Long, well sprung, close	2		
Back—Short, broad, strong	2		
Loin—Short, wide, muscular	2		
Flanks—Deep, full; long, low underline	1		

Score Card for the Mule—Continued.

Scale of points.	Standard score.	Points given animal judged.	
		Student's score.	Corrected score.
HIND QUARTERS—32 points:			
Hips—Wide, level, smooth, muscular	2		
Croup—Long, level, muscular	2		
Tail—Set high, well carried	1		
Quarters and thighs—Deep and muscular; strongly joined to gaskins	3		
Stifles—Broad, thick, strong	1		
Gaskins—(Lower thighs) long, wide, muscular	2		
Hocks—Straight, wide, prominent points, deep, flat, clean-cut, well supported	6		
Cannons—Similar to front, but a trifle longer and wider	2		
Fetlocks—Wide, straight, tendons well back	2		
Pasterns—Similar to front, but less sloping (about 55°)	3		
Feet—Similar to front, but not quite as large	4		
Leg position—From rear, a perpendicular line from point of buttock should divide the leg and foot into lateral halves; from the side, this same line should touch the point of hock and run parallel to the cannon. A similar line from hip joint should meet the ground midway between heel and toe	4		
ACTION—12 points:			
Walk—Active, straight, balanced, long stride	7		
Trot—Straight, long, free, regular, snappy stride	5		
Total	100		

MARKET CLASSES OF MULES.

Mules are classified according to their use. There are many local market classifications of mules, but they may be grouped into five general classes. Each class includes mules of a general type, while there are various grades and weights within a specific class.

The general classes of mules are shown in the table.

TABLE 2.—*Ranges in height and weight of various classes of mules.*[3]

Class.	Range in height.	Range in weight.
	Hands.	*Pounds.*
Draft	16 to 17½	1,200 to 1,600
Farm	15½ to 16	900 to 1,250
Sugar	16 to 17	1,150 to 1,300
Cotton	13½ to 15½	750 to 1,100
Mining	12 to 16	600 to 1,350

Each of the classes is graded according to conformation, soundness, quality, condition, and action into the following grades: Choice, good, medium, common, inferior.

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[3] Market Classes and Grades of Horses and Mules. Bulletin 122, Illinois Agricultural Experiment Station, 2d ed. 1912.

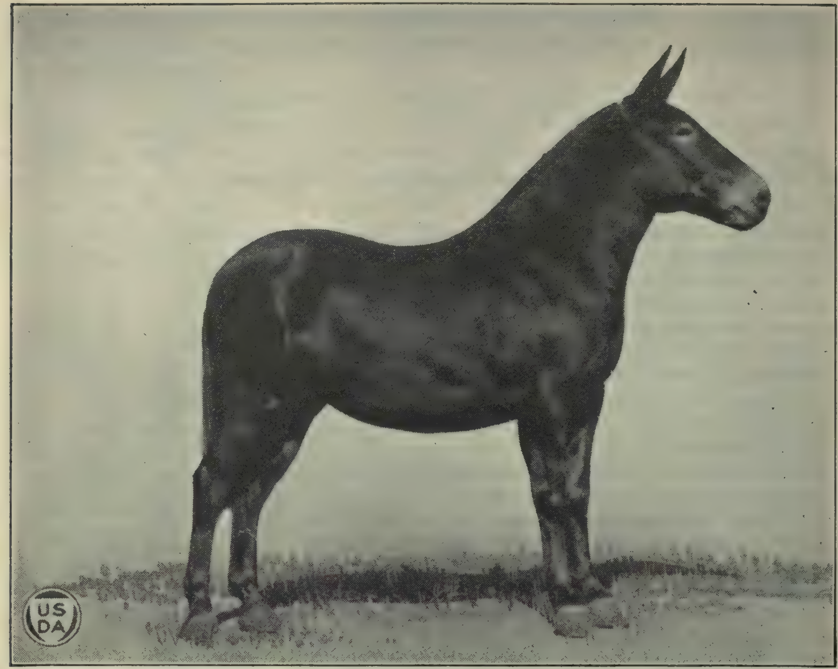

FIG. 8.—A choice draft mule. Champion mule at American Royal Livestock Show, Kansas City, Mo., 1922.

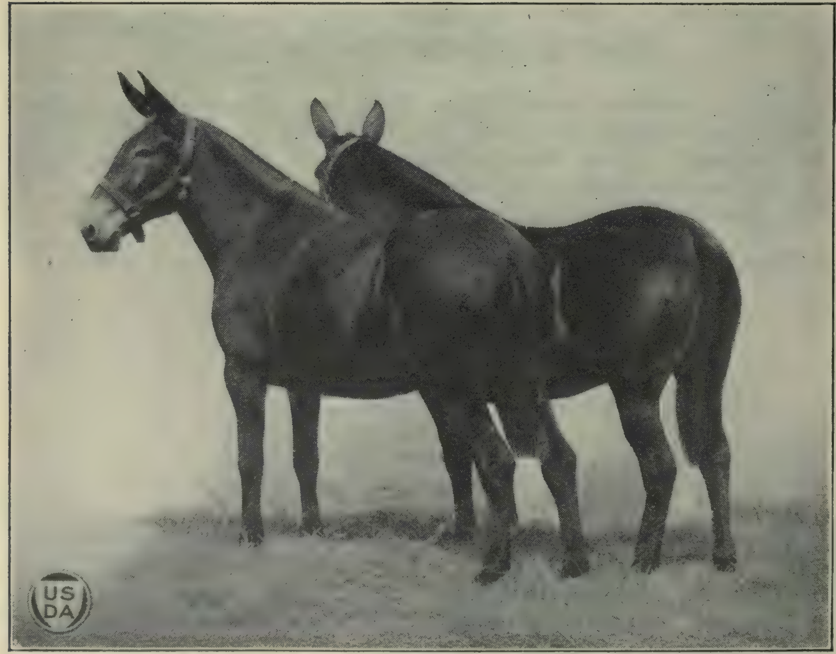

FIG. 9.—A pair of choice draft mules.

DRAFT MULES.

The draft-mule class includes the largest mules (Figs. 8, 9, 10), standing from 16 to 17½ hands and weighing from 1,200 to 1,600 pounds. Some exceptional draft mules exceed the maximum weight given for this class. They are used largely for heavy teaming in large cities, especially in the warmer climates; for contract jobs, such as road grading and railroad work; and for lumber work. Mules for contract work are usually designated by an appropriate descriptive name, such, for instance, as "railroaders." The heaviest draft mules find their way to the lumber camps. Contract mules must have more quality than lumber mules, but extreme weight is not so essential. The greatest demand for draft mules is for those between the ages of 5 and 8 years.

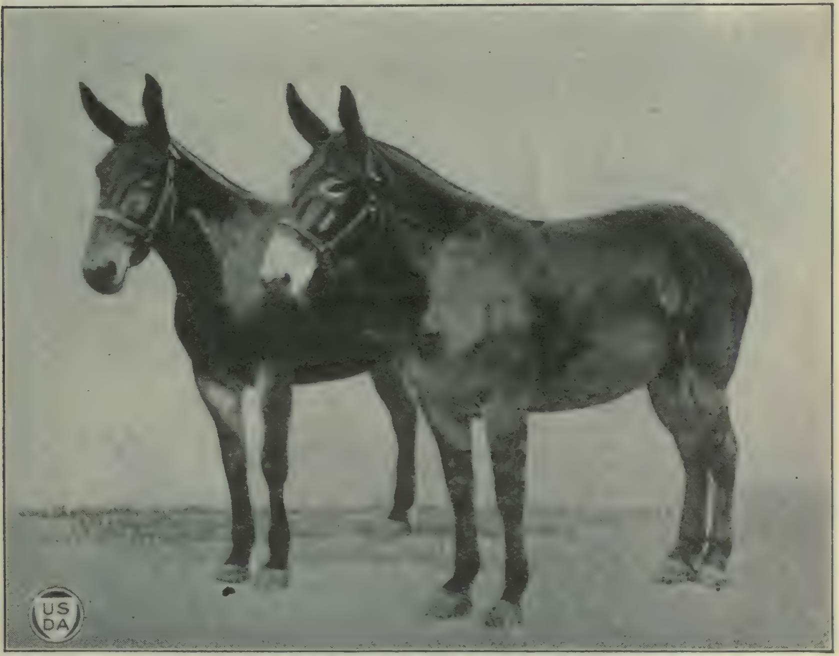

FIG. 10.—A pair of good draft mules.

There is no special preference in regard to sex. The highest prices paid are for those mules having weight combined with heavy bone, large, well-shaped feet, strong, short backs, closely coupled with abundant muscling over the loin and hind quarters.

FARM MULES.

Mules purchased in the market for farm work in the Middle Western States are known as "farm mules." There is more variation in quality and type in this class than in any other class, as the demand for a specific type is not so well defined (Figs. 11, 12, 13, 14).

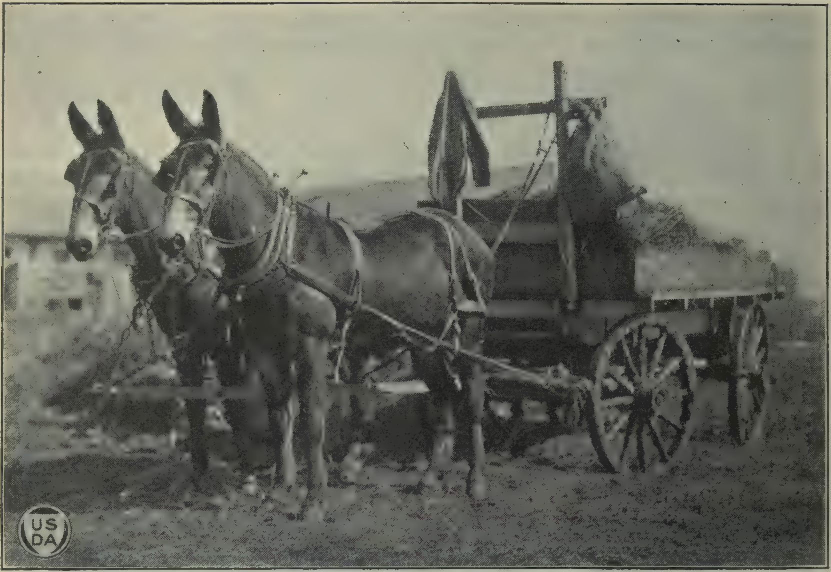

FIG. 11.—A pair of large farm mules.

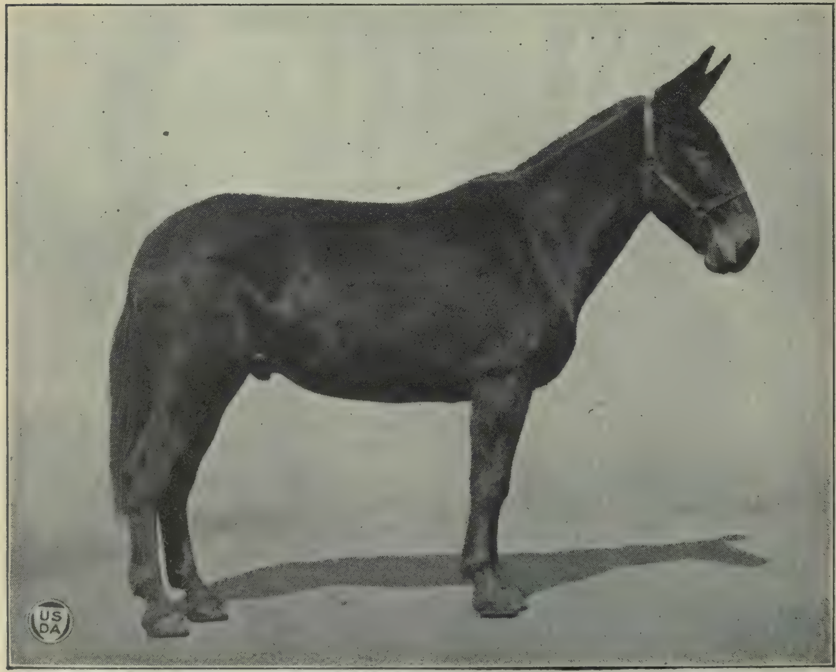

FIG. 12.—A good farm mule.

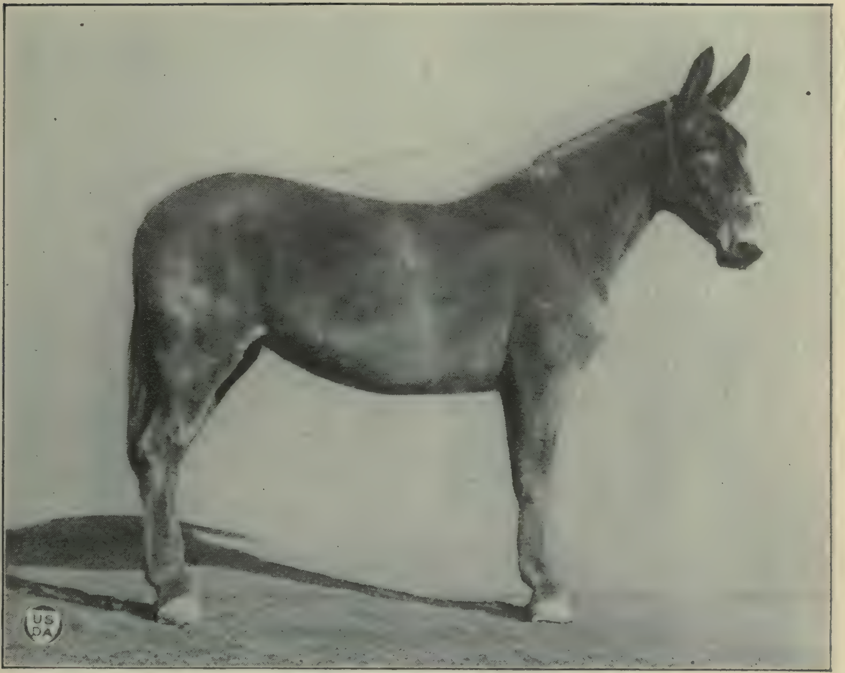

FIG. 13.—A medium farm mule.

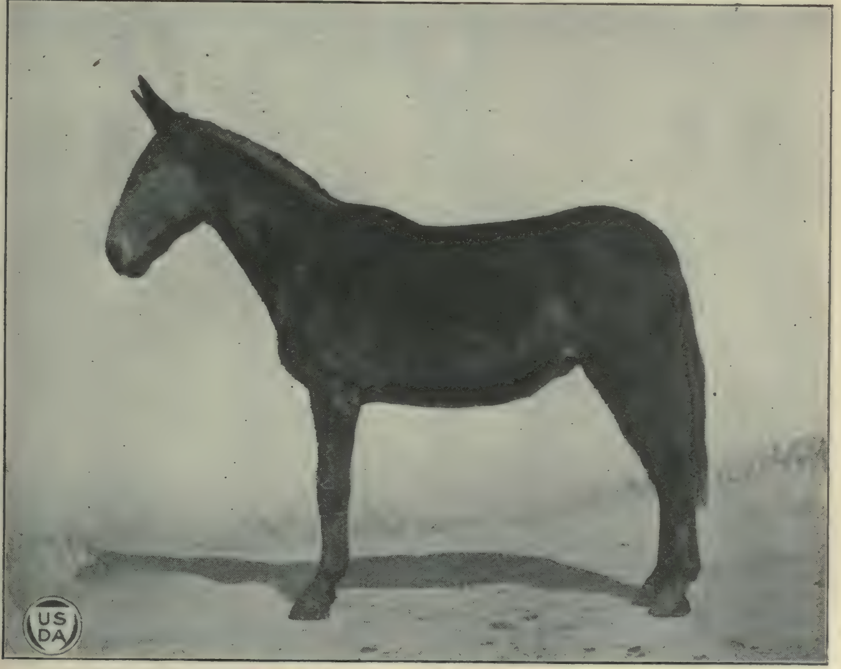

FIG. 14.—Common farm mule.

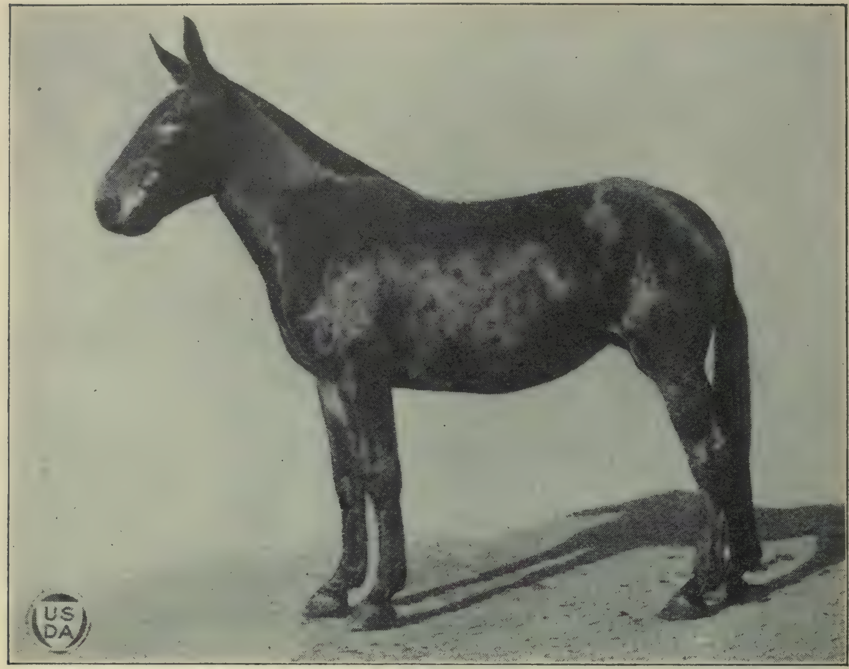

FIG. 15.—A choice sugar mule.

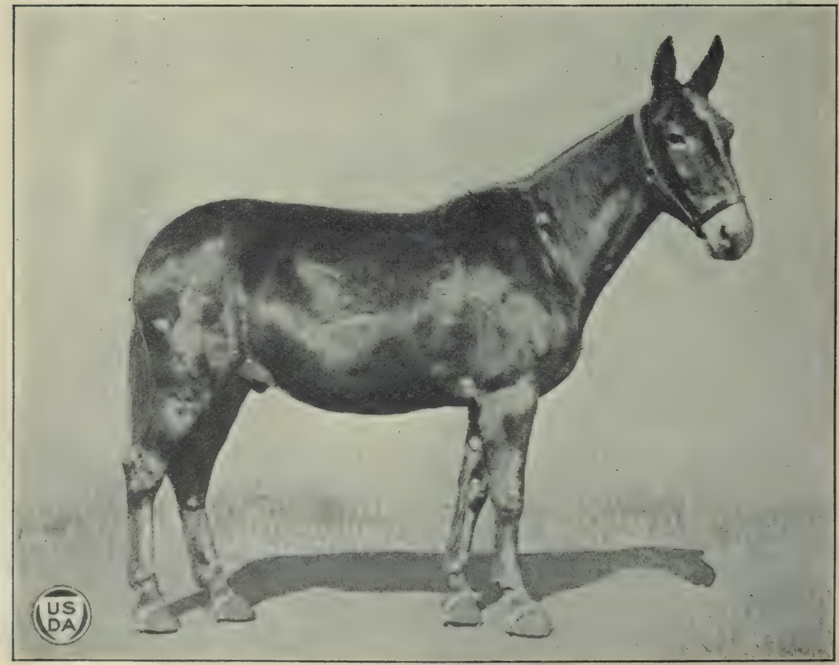

FIG. 16.—A good sugar mule.

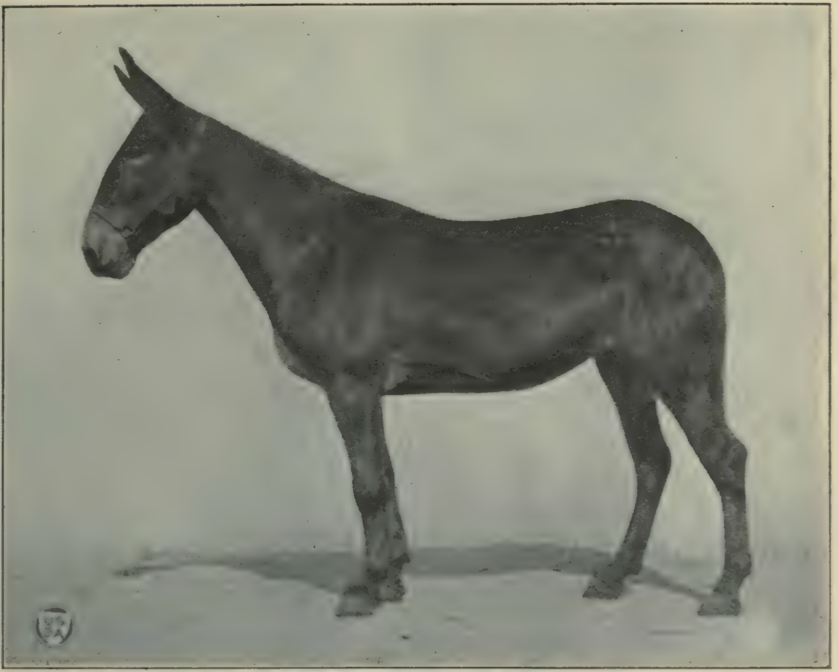

FIG. 17.—Common sugar mule.

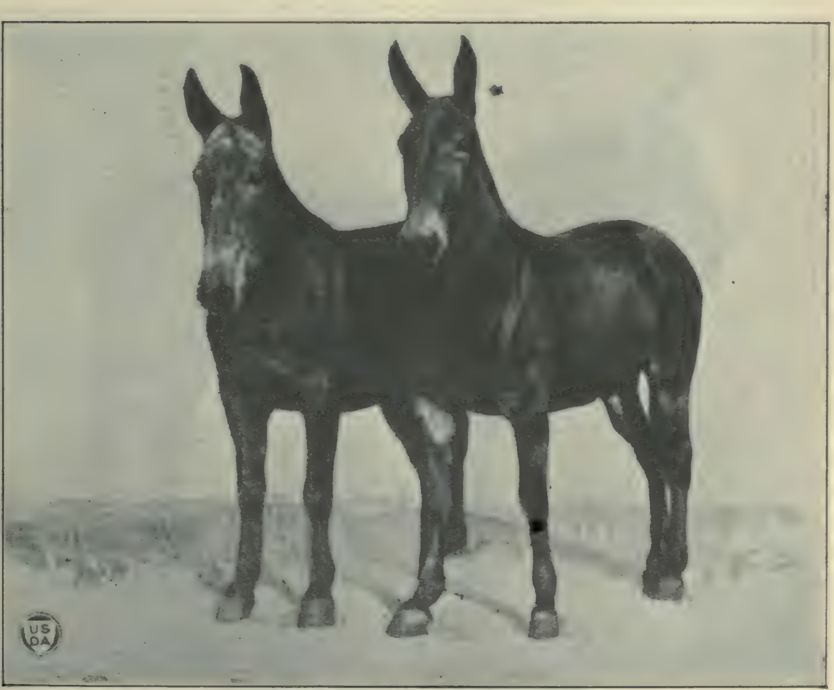

FIG. 18.—A team of choice cotton mules.

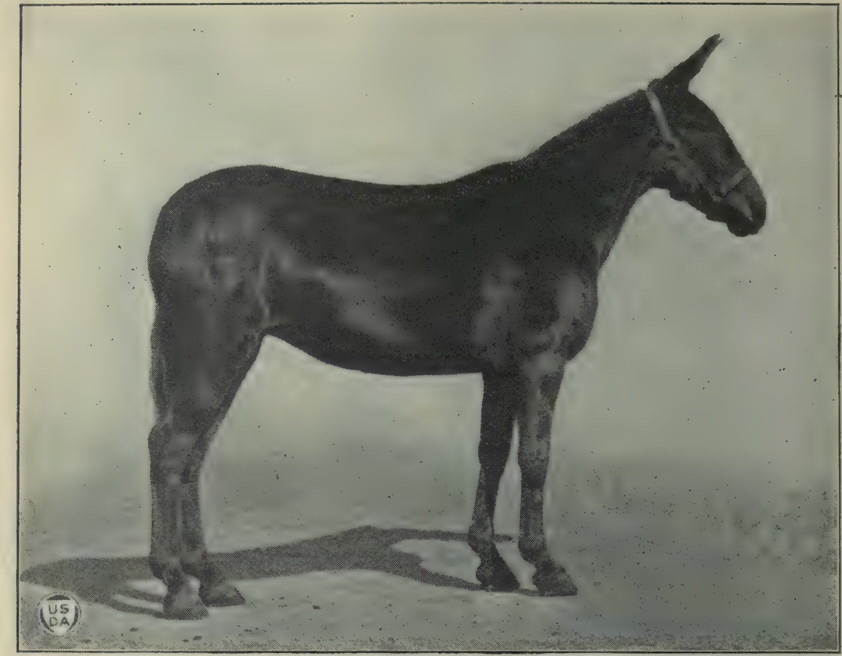

FIG. 19.—A good cotton mule.

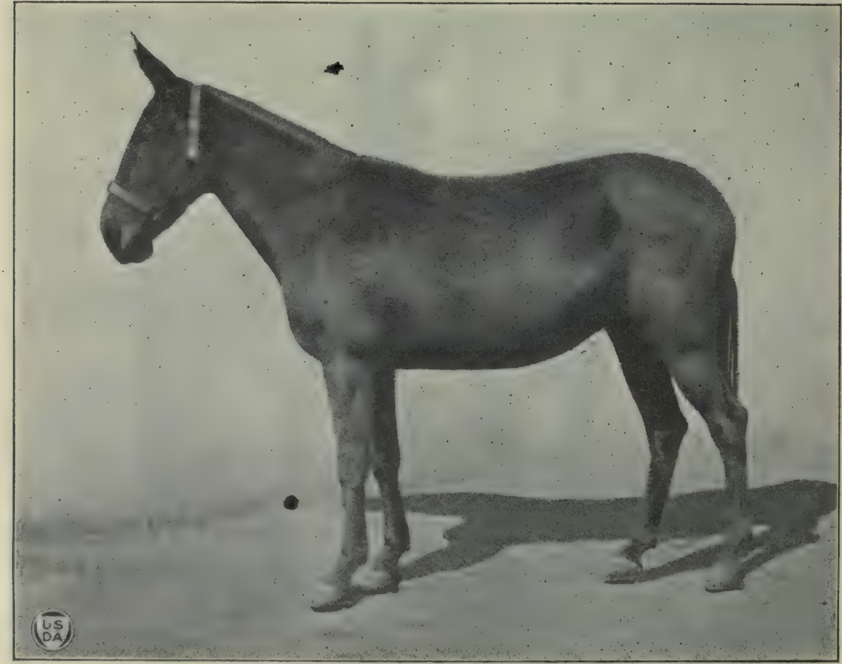

FIG. 20.—A medium cotton mule.

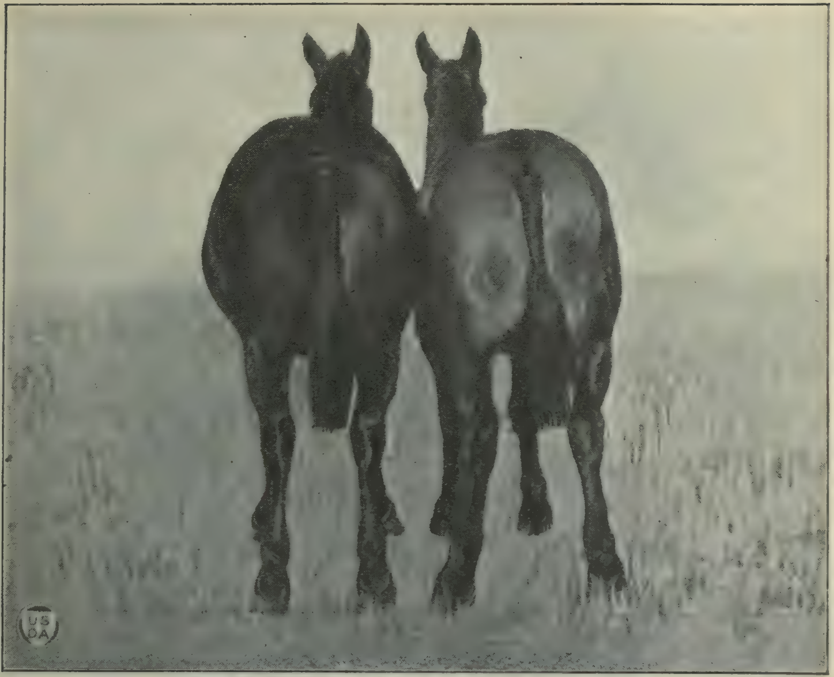

FIG. 21.—A team of choice surface mining mules.

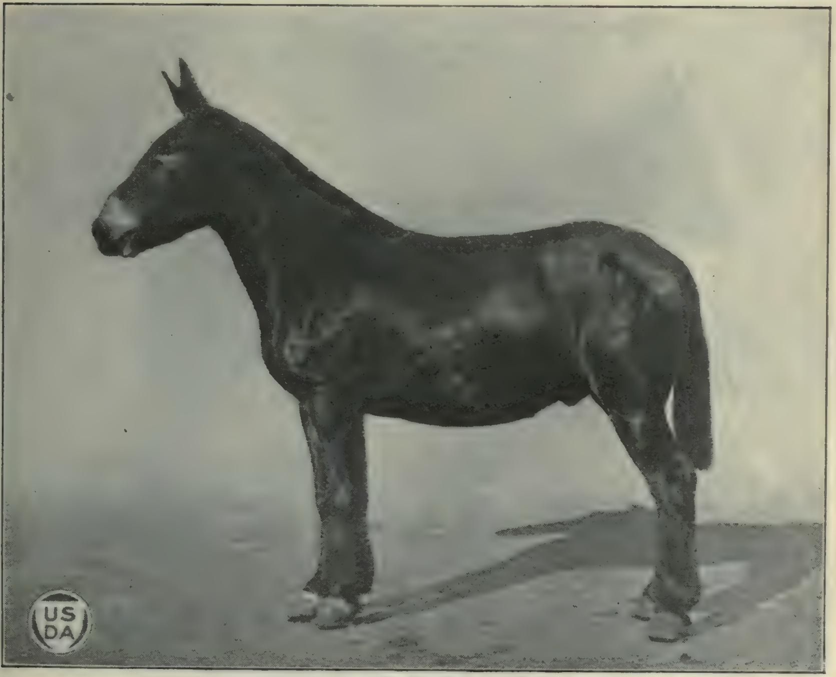

FIG. 22.—A choice surface mining mule.

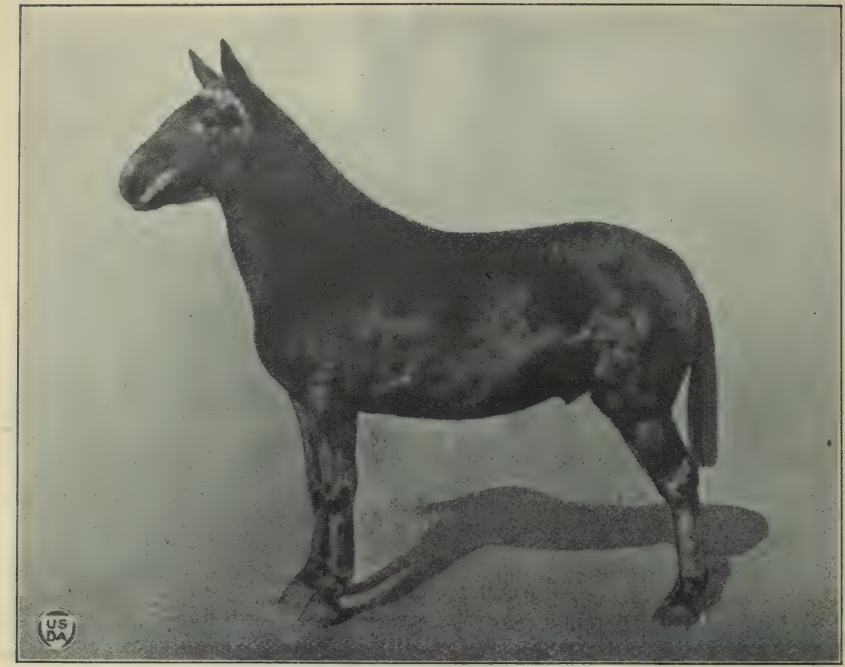

FIG. 23.—A choice pit mining mule.

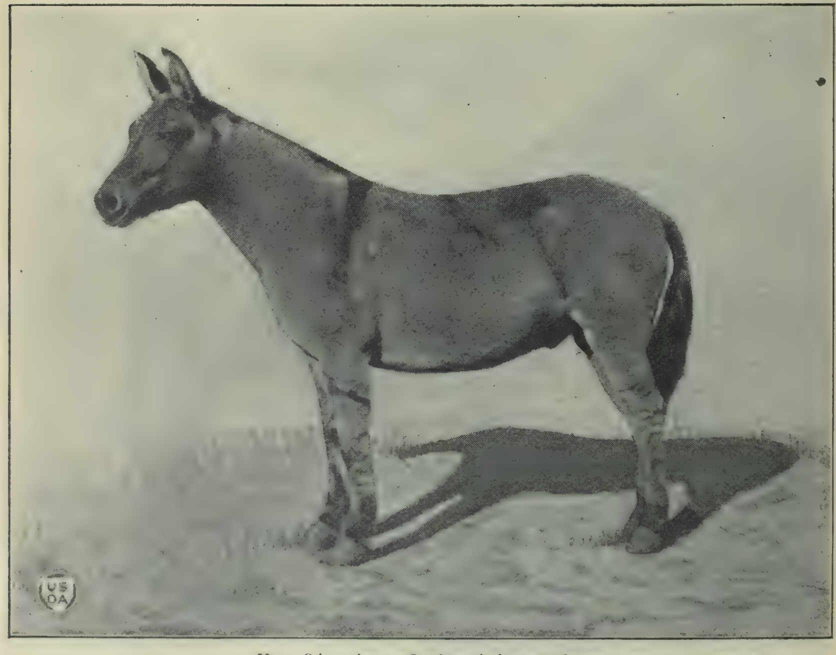

FIG. 24.—A good pit mining mule.

Mules in this class may be plain draft mules or cotton mules that lack finish and condition, as the farmer likes to buy mules with a prospect of developing them into more valuable animals. Many of them are worked for a season and then fitted for the market, where they are placed into one of the other specific classes, such as " drafters," " sugar mules," " cotton mules," " miners," or "railroaders."

SUGAR MULES.

Sugar mules are those which are purchased for shipment to the sugar plantations of the South. This class of mules is somewhat rangy in type and should have quality, style, and finish. The mules in this class are heavier and more compact than cotton mules, but not so heavy as draft mules. The range in weight is from 1,150 to 1,300 pounds. In selecting sugar mules special attention should be given to quality and adaptability to the work. The feet should be large and well shaped. Mare mules are preferred for the sugar trade (Figs. 15, 16, 17).

COTTON MULES.

As the name implies, cotton mules are purchased for cotton plantations. The type (Figs. 18, 19, 20) is somewhat lighter and more angular than the sugar or surface-mining mule and heavier than the pit mule. While there is a gradation of quality and age in this market class, the planters of the South are becoming more and more inclined to increased weight and quality in their mules than prevailed a few years ago. A choice cotton mule weighs about 1,150 pounds and is alert and active, but most mules in this class vary from 750 to 1,100 pounds. The custom in the Cotton Belt is to buy mules in the spring for the crop season and dispose of them in the fall. As they are usually in poor condition following the heavy summer's work, they are sold in the fall for a fraction of the purchase price. These mules are wintered, fattened, and sold back to the planter in the spring. For this reason the age limits within this class are variable. Mules from 5 to 7 years old are preferred, however, for this trade and bring the best prices.

MINING MULES.

There is a wide range in weight among mining mules, varying from 600-pound pit mules to 1,350-pound surface mules (Figs. 21, 22, 23, 24). Good feet and freedom from blemishes are requirements for mules to qualify for top prices for the mining trade.

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U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1342

DAIRY-BARN CONSTRUCTION

THE plan, construction, and equipment of a dairy barn should receive careful consideration and study in order that the building may best serve its purpose, and also to avoid as far as possible having to make expensive alterations which otherwise might become desirable or necessary.

A well-planned and equipped barn saves time and labor for the farmer, and provides comfortable quarters for the cows, while the poorly planned barn is a daily source of annoyance and of wasted time and energy. It is important, then, that dairymen become familiar with the best principles of barn construction and the most satisfactory types of equipment, before building or remodeling their barns.

The subject covers such a large field that only the principal features of modern construction and equipment, together with practical plans for various types and sizes of dairy barns, will be presented in this bulletin.

Washington, D. C. October, 1923.

DAIRY-BARN CONSTRUCTION.

By K. E. Parks, *Dairy Engineer, Dairy Division, Bureau of Animal Industry.*

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TYPE OF BARN TO SELECT.

There are so many considerations which enter into the selection of the best type of barn for any particular case that the dairyman will usually have to rely on his own judgment as to what sort of barn will best meet his needs. Some of the more important factors to consider are climate, topography, drainage, location relative to other buildings, size and stage of development of his dairy project, fire risk, materials available for construction, and local regulations covering the production, handling, and disposal of milk. Of the various types of dairy barns only two of the most common will be described, as the others, with the possible exception of the round and octagonal types, are mainly modifications of these.

The most common types of modern dairy barns are the one-story cow stable, with feed in a separate building, and the two-story barn, in which the feed is stored on the floor over the cows. In the colder sections of the country the two-story barn is usually preferred, while in the South and in moderate climates the one-story barn is more common. Whatever the type of barn selected, there are certain features common to all, and these will be described before going into the details of construction.

THE BUILDING SITE.

A building site should be selected which is dry and well drained, and, if possible, the building should be placed with its length extending north and south, so that the interior of the barn will receive the most sunlight. Such an arrangement allows the morning and afternoon sun to enter the windows on the sides and provides the greatest amount of light. The barn should be so placed in relation to other buildings that the sunlight will not be obstructed from the east, south, or west. A windbreak of trees or buildings on the north or in the direction of the prevailing cold winds will be found a great advantage in the winter.

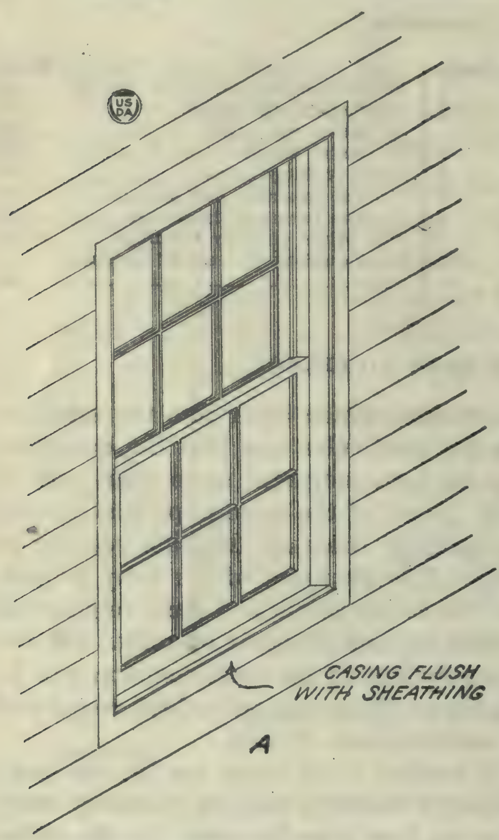

FIG. 1.—Twelve-light stock window.

Another point to consider in selecting the building site is its accessibility for unloading hay and feed and filling the silo, and the arrangement of yards and lanes. It is very inconvenient to have to drive through gates and yards to fill the silo or feed barn, and with careful planning it is generally possible to arrange the yards so that this will be unnecessary.

ESSENTIAL FEATURES IN DAIRY-BARN CONSTRUCTION.

After selecting the type of barn and the building site, the next step is to plan a building of the proper size and shape to house the stock and feed, fit the location selected, and at the same time harmonize with other buildings. The arrangement of the barn should be such that the daily work of caring for the animals can be accomplished with the least expenditure of time and labor. To accomplish this requires careful consideration of the location of the feed barn, silo, and milk house, and the method that will be used in handling manure.

In a cow stable there are certain features, such as light, floor space, ventilation, air space, stalls, mangers, and gutters, which are generally recognized as essential.

LIGHT.

Sunlight is considered essential to the health of the dairy cow, and it also tends to destroy disease germs which may be found in dark and dirty stables. It is necessary, therefore, that ample window space be provided. Four square feet of glass per cow is desirable, and a much larger amount is preferable, except in extremely cold climates. The height of the windows should always be greater than their width, as more floor area is exposed to the sun this way than with low, wide windows. In the Northern States objection is sometimes made to the use of too much glass on account of the loss of heat through the windows, which tends to lower the temperature of the barn. This difficulty may be remedied by using storm sash in the winter or by using double-glazed sash; either of these is better than small windows, which do not flood the barn with sunlight.

In a barn extending north and south, 12-light windows of 8 by 12 inch glass, spaced 7 feet from center to center along the side walls, will provide 4 square feet of glass for each cow and will light a barn 36 feet wide in a very satisfactory manner. Windows should be placed with the sills at least 4 feet above the floor.

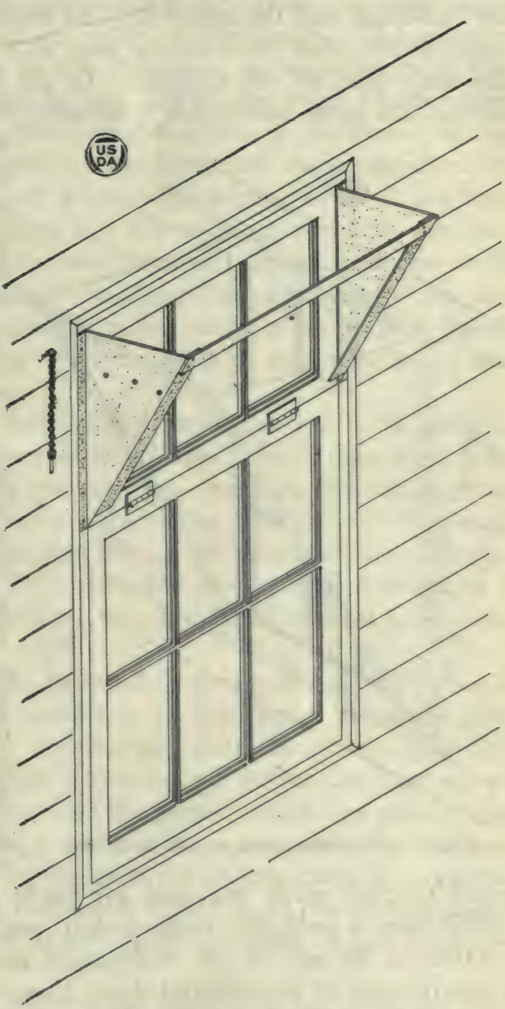

FIG. 2.—Six-light sash, with 3-light transom (to tip in).

Figures 1, 2, and 3 show three types of windows suitable for cow stables. Figure 1 is the regular stock, 12-light window, while Figures 2 and 3 are windows which provide better ventilation.

AIR SPACE.

While the amount of cubic air space per cow in a stable is not necessarily an indication of either good or bad ventilation, it is considered desirable to have not less than 500 nor more than 1,000 cubic feet for each animal. In the North from 500 to 600 cubic feet are sufficient, and the stable may be uncomfortably cold if more air space is provided than can be kept at a reasonable temperature by the body heat of the animals. In the South 1,000 cubic feet per animal are more satisfactory, because of the long period of warm weather. A stable 36 feet wide, outside measurement, should have a ceiling 8 or 9 feet from the floor in order to furnish from 500 to 600 cubic feet of air space per cow.

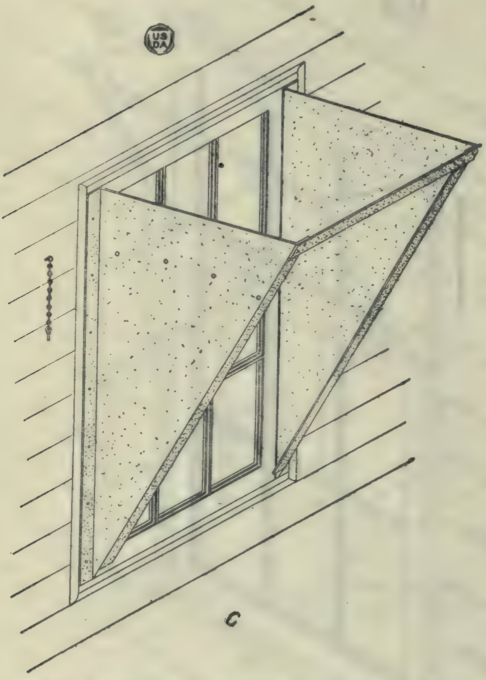

Fig. 3.—Nine-light sash, to tip in at top.

VENTILATING SYSTEMS.

The system of ventilation commonly used in cow stables is known as the King system, from its originator, Prof. F. H. King, of the University of Wisconsin. The system is designed to remove the foul air from the stable and at the same time provide for the entrance of fresh air through flues. It operates on the principle that warm air, being lighter than cold air, tends to rise, while the cold air tends to settle. This system of ventilation is probably more widely used than any other.

Often a failure of the ventilating system is due to improperly proportioned or constructed flues, loose-fitting doors and windows, and during an extended period of extreme cold weather to the clogging of the outlet flues with ice formed by the condensing and freezing of moisture thrown off by the animals. If properly constructed, the King system is generally very satisfactory.

In constructing such a ventilating system each outlet flue should have an area of approximately one-fifth square foot per cow, with possibly less area in cold climates and more in warm climates; that is, a flue having an area of 1 square foot should be considered sufficient for 5 cows, and a flue 2 feet square, having an area of 4 square feet, would provide for 20 cows. The area of outlet flues is based on the principle that the air will rise in the flue at a certain rate or velocity, thus removing from the stable a certain number of cubic feet of air per minute. An equal amount of fresh air is drawn in through the inlet flues, thus establishing air circulation and maintaining a certain standard of air purity in the stable. The velocity of the air depends not only on the difference in temperature of the air inside and outside the stable, but also on the wind which blows across the top of the outlet flues and the action in the flues. While the amount of foul air removed by the flues may vary considerably, the cows continue to give off a constant supply of foul air and moisture, and if the outlet flues are not working properly the foul air will not be removed and the moisture will condense on the walls or ceilings, causing the stable to be damp and unhealthful for the cows. This condition, however, is more likely to occur in a stable where there is no ventilating system, and it is not wise to depend on window ventilation alone.

One or two large outlet flues of sufficient area are more efficient than a number of smaller ones of equal area. Such flues should be air-tight and as straight as possible, for bends in the outlet flues cause air friction which greatly reduces the flow of air. If bends are necessary, the area of the flue should be increased accordingly. In extremely cold climates the outlet flue should extend down to a point 12 or 18 inches from the floor, but in mild climates it need come only to the ceiling.

The fresh-air intakes should be small in area and should be placed from 7 to 10 feet, or, where necessary, 12 feet, apart along the side walls. These flues should be so arranged that the openings on the outside of the building through which the air enters the flues are at least 5 feet below the openings into the stable, which are placed just below the ceiling. The reason for arranging openings in this manner is to prevent the warm air inside near the ceiling from leaving the building through the intake flues, as it would do if the outside opening were at the same height as the opening inside of the barn, or higher.

In extremely cold climates the intake should be less than the outlet; but under most conditions the total area of all the inlet flues should be approximately equal to the total area of the outlet flue or flues; for example, if the outlet flue has an area of 4 square feet, the total area of the intake flues should equal 4 square feet. In a barn having one outlet flue 4 square feet in area there would probably be five inlet flues on each side, or 10 in all, each having an area of one-tenth of 4 square feet, or 57.6 square inches. Inlet flues 4 inches

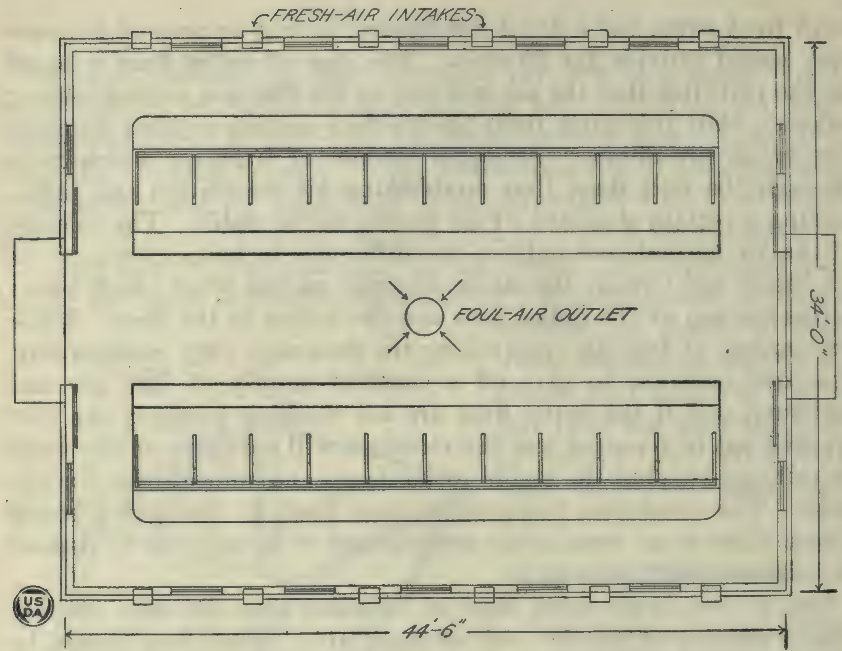

FIG. 4.—Plan of one-story cow stable, showing arrangement of ventilating flues.

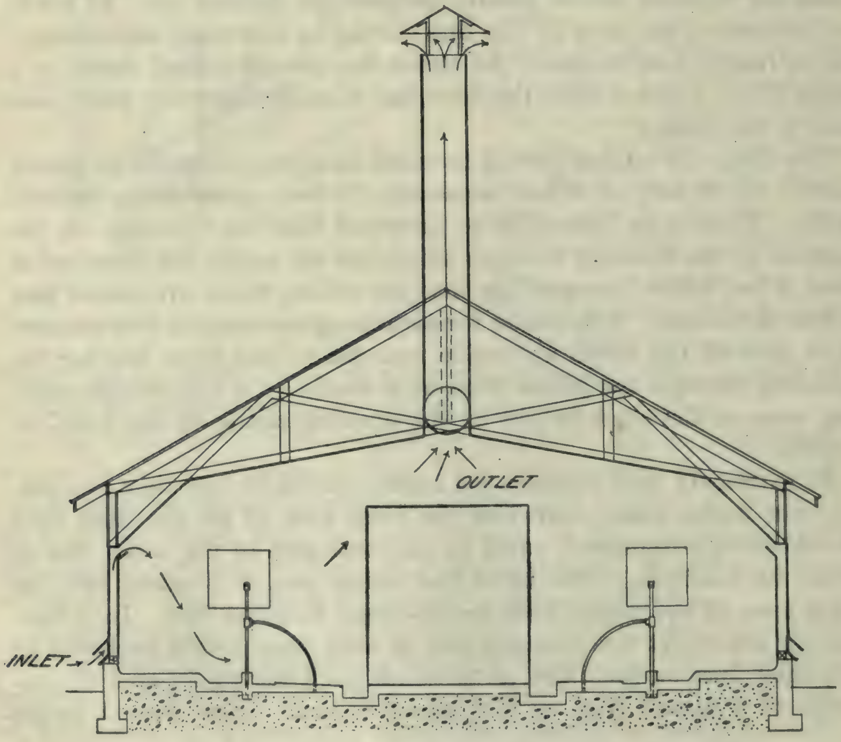

FIG. 5.—Cross section of one-story cow stable, showing ventilating flues.

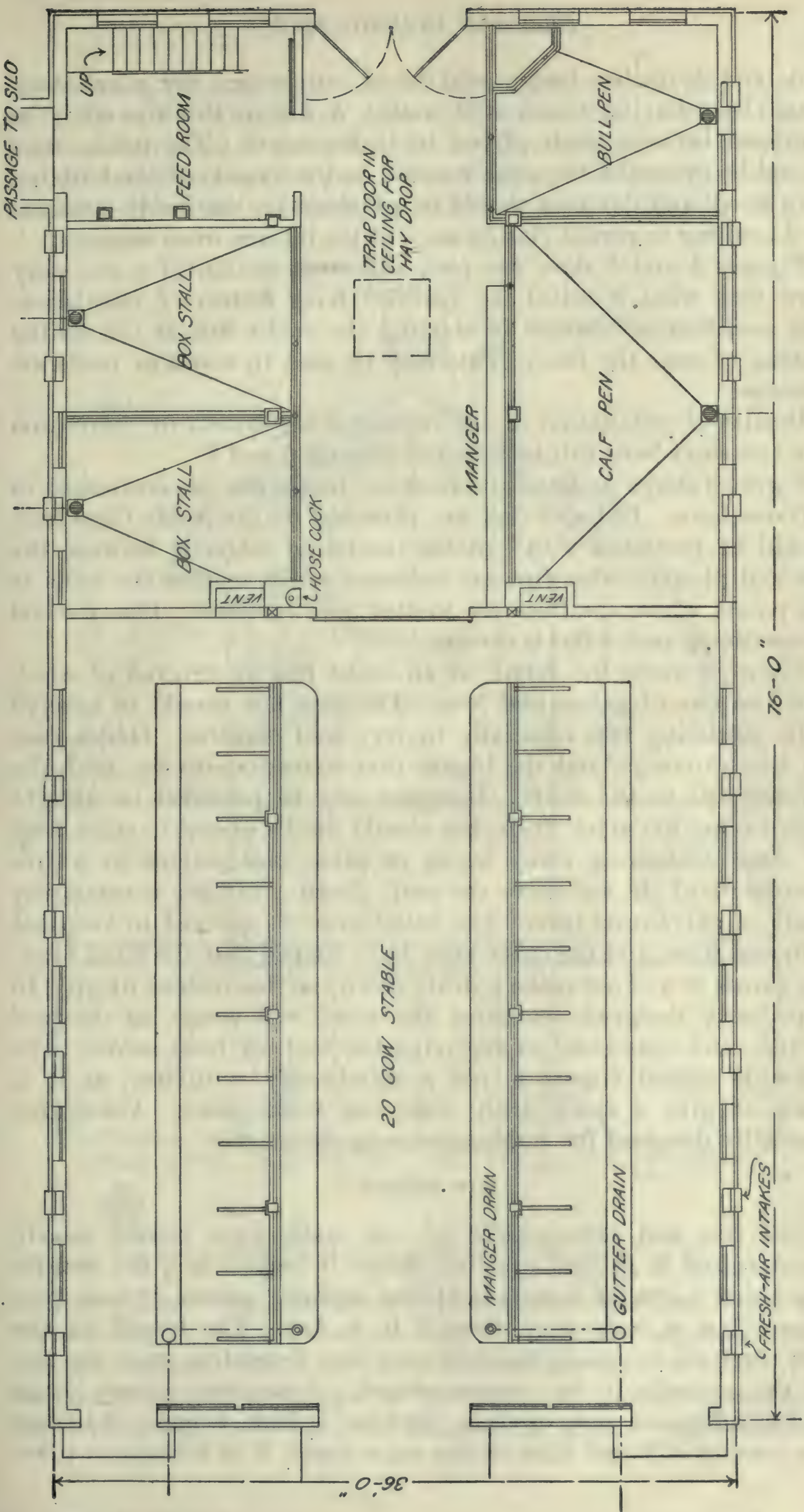

FIG. 6.—Plan of two-story barn, showing ventilating flues.

wide and 16 inches long would be of proper size for a one-story frame barn having 4-inch stud walls. A flue of this size could be arranged between studs placed 16 inches apart. The intake flues should be protected from the weather on the outside of the building by a hood, and dampers should be provided on the inside openings at the ceiling to permit closing some of the intakes when necessary.

Figures 4 and 5 show the plan and cross section of a one-story barn with what is called the modified King system of ventilation. The modification consists in starting the outlet flue at the ceiling instead of near the floor. This may be used in warm or moderate climates.

Details of installation of the regular King system of ventilation in a two-story barn will be found in Figures 6 and 7.

Figure 8 shows in detail the fresh-air intake flue as constructed in a frame barn. In barns that are plastered on the inside these flues should be protected with suitable insulating material between the flue and plaster; otherwise any moisture which touches the walls at the points where the flues are located will condense. One method of insulating such a flue is shown.

Figure 9 shows the details of an outlet flue constructed of wood, and also one of galvanized iron. The iron flue should be covered with insulating felt, especially in very cold climates. Outlet flues act like chimneys, and the higher they extend above the roof, the greater will be the draft. Dampers may be provided in straight flues having too much draft, but should not be placed in short flues or those containing many bends or other obstructions to a free circulation of the air above the roof. Such a damper is commonly made of galvanized iron. The outlet must be covered to keep out rain and snow, and the cover must be so shaped that the wind blowing across it will not make a draft down the flue instead of up. In a properly designed ventilator the wind will create an outward suction, and thus assist in removing the foul air from below. The old-style slatted cupola is not a satisfactory ventilator, as it is liable to give a down draft when the wind blows. Ventilators especially designed for stable use are on the market.

COW STALLS.

The size and arrangement of cow stalls have become nearly standardized in general practice, except in respect to a few details. The usual width of a stall is 3½ feet between centers of stall partitions, but it may vary from 3 to 4 feet. The length of the cow platform is usually from 4½ to 5 feet, depending upon the size of the animals to be accommodated. Sometimes a very large Holstein-Friesian cow needs a platform a little longer. As there are cows of different sizes in the same breed, it is a common practice to vary the length of the platform from one end of the row of stalls to the other. For Jerseys, this variation is from 4 feet 4 inches at one end to 4 feet 8 inches at the other; and for Holsteins from 4 feet 8 inches to 5 feet. The length of the cow platform is measured from the inside of the stanchion curb to the edge of the manure gutter. Manufacturers of cow-stable equipment have adjustable devices which permit moving the stanchion supports either forward or backward to accommodate various sizes of cows. The reason for varying the length of the platform or using these aligning devices is to keep the cows lined at the gutter when standing,

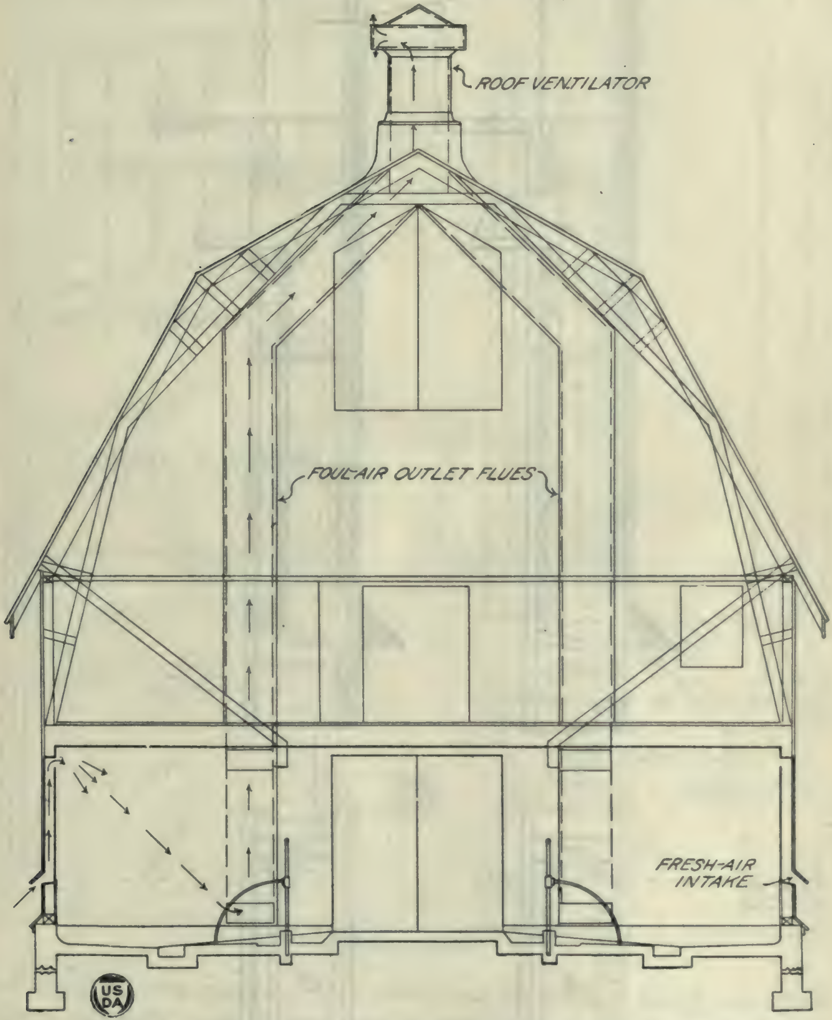

FIG. 7.—Cross section of two-story barn, showing ventilating flues.

so that the manure will fall in the gutter and not on the platform where they have to lie down.

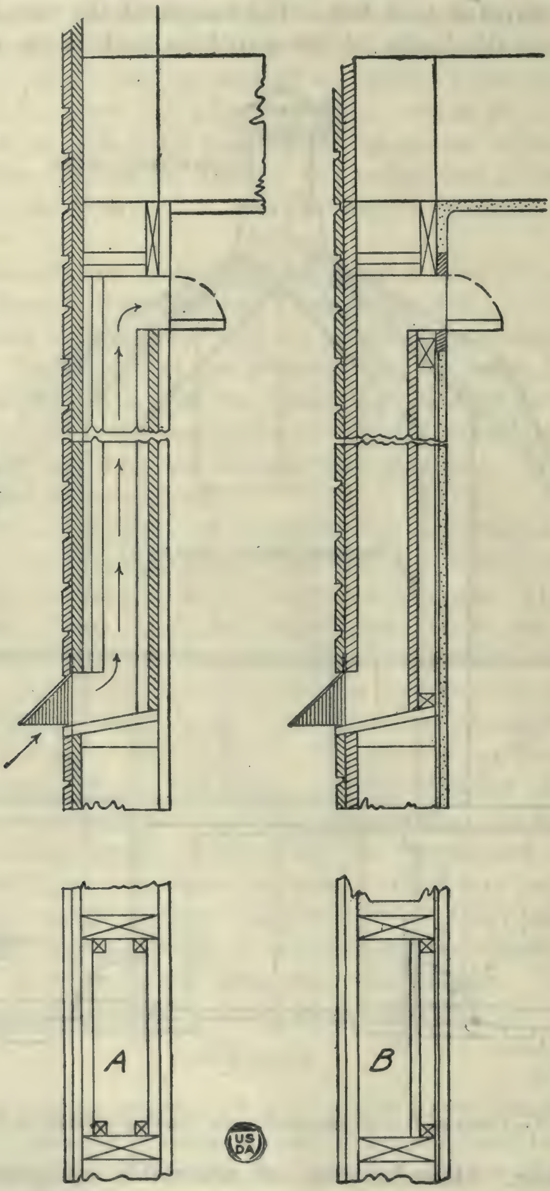

FIG. 8.—Details of inlet-flue construction: *A*, for barn with wood sheathing on inside walls; *B*, for barn with plastered inside walls.

To a certain extent the desired result is accomplished, but cows will usually become soiled even in a stall of this kind and will, of course, need to be groomed before milking.

The shape and size of the gutter and manger are points about which there is not full agreement. However, a good type of manger and gutter for a commercial dairy barn is indicated in Figure 10, which shows a cross section through a cow stall, the dimensions of which have proved satisfactory.

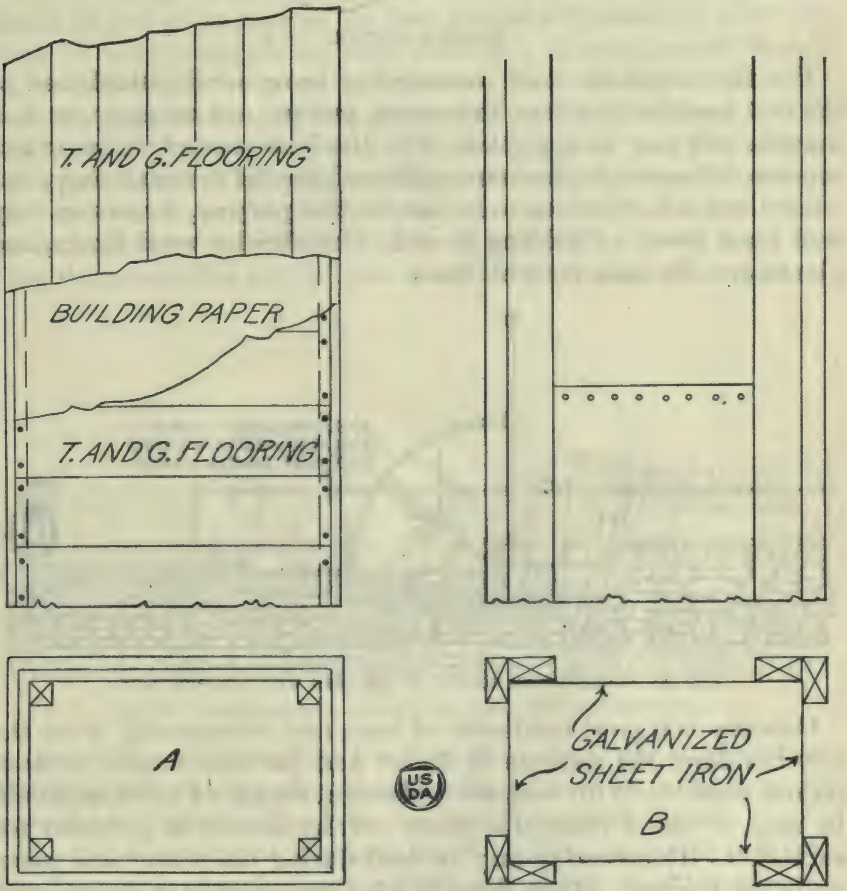

Fig. 9.—Details of outlet-flue construction: *A*, wood construction; *B*, galvanized-metal construction.

Figure 10 also shows the construction of stalls. Many manufacturers can now supply these stalls complete, to be assembled with clamp fittings, which save considerable time and labor in erection, as compared with the older method of using screwed pipe fittings.

STANCHIONS.

Comfort for the cow is important. The old-fashioned rigid wooden stanchion in which the cow was pilloried a portion of each day for a considerable part of the year has been replaced by the swinging stanchion, which gives the cow more freedom and allows her to rest in a natural position. Such stanchions may be obtained in either steel or wood. The former is considered more sanitary, but has the disadvantage of being cold for the cow's neck unless the surrounding air is amply warm. A wooden lining to the steel stanchion may be used to overcome this objection.

STABLE FLOOR.

For the cow-stable floor concrete has become well established as the best material in alleys, driveways, gutters, and mangers, as it is durable and may be kept clean with the least amount of labor and expense. Concrete is also commonly used for the cow-stall floor, and while there are objections to its use for this purpose, it answers very well when plenty of bedding is used. Cork bricks, wood blocks, and planks are also used for stall floors.

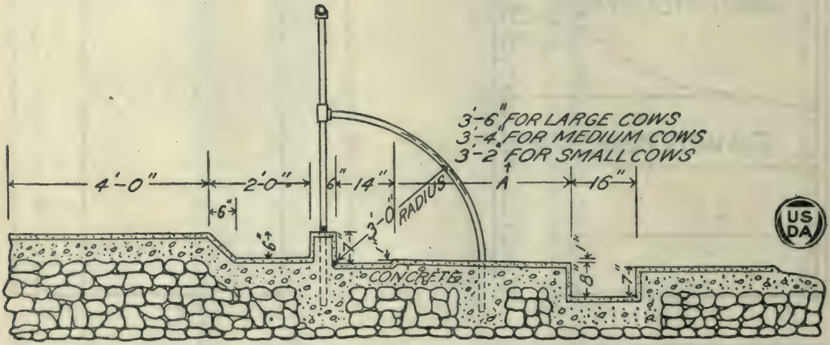

FIG. 10.—Longitudinal section of cow stall with concrete floor.

Concrete is a good conductor of heat, and consequently when the cow lies down the concrete chills her and has been known to cause serious trouble. With concrete a plentiful supply of bedding should be used, or else a removable plank overlay should be provided for each stall. This overlay may be used during the winter and taken up in the summer. Plank floors bedded permanently in the concrete are not satisfactory, as they soon become insanitary.

Cork brick, while expensive in first cost, makes an excellent floor when laid as shown in Figure 11. Formerly the bricks were laid with a 4-inch concrete curb at the edge of the gutter, but many cows have been injured on this kind of curb. When an angle iron is used as shown no trouble has been experienced.

Creosoted wood blocks have been used for cow-stall floors. They have to be laid in hot asphalt or pitch, as they swell when wet and would not have proper allowance for expansion if laid in cement.

Especial care should be exercised in laying the concrete floor of a dairy barn, as a floor which is not properly pitched to drain, and is not properly finished, will be a constant source of annoyance and may result in injury to some of the animals.

In driveways and alleys, where teams or heavy silage trucks are to be used, the floor should be 6 inches thick, the base being 5 inches and the top finish 1 inch thick. All other parts of the floor may be 5 inches thick, with a 4-inch base and a 1-inch finish. The finish should be put on as soon as the base has set sufficiently to allow the finish to be applied; and on large floors only so much should be laid in one day as may be properly finished. The base may consist of 1 part Portland cement; 2½ to 3 parts clean, coarse sand; and 5 parts broken stone or screened gravel. The finish should be 1 part cement and 2 parts sand. The manger and gutter should be troweled smooth and hard on the surface with a steel trowel, while all alleys where the animals have to walk should be floated with a wood float, and when the cement has partially set it should be marked off in squares, or thoroughly roughened with a wire brush or a whisk broom partially cut off. Roughening these walks is very important, as the animals are liable to slip if the concrete is troweled smooth.

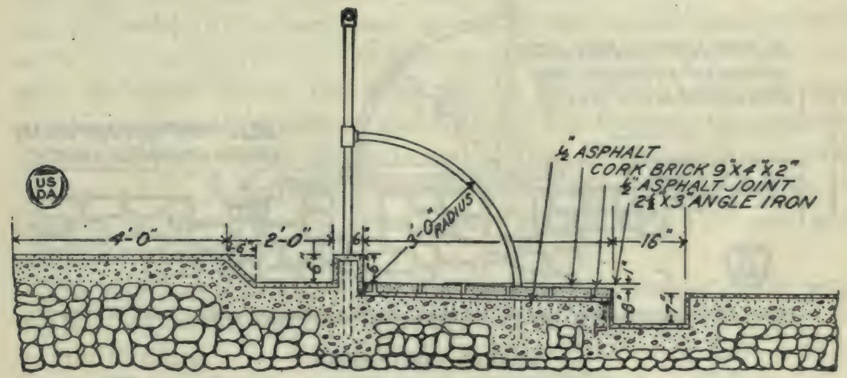

FIG. 11.—Longitudinal section of cow stall with cork-brick floor.

In a stable not over 50 feet long the whole floor, including mangers, stanchion curb, cow platform, gutters, and alleys, should have a fall from one end of the building to the other of about 1 inch in 10 feet. In longer barns it may be desirable to pitch from the ends to the center. At the low end a drain should be provided from the manger to the gutter, and a gutter drain connected to glazed terra-cotta sewer pipe to carry the wash water away from the building.

These drains should be fitted with brass or wood plugs, and the gutter drain should have a water-sealed bell trap if the sewer pipe is connected to any sort of a cesspool or other sewage-disposal plant. Figure 12 shows a section through the manger and gutter drains.

Gutter drains are sometimes arranged so that the liquid manure will be collected in a concrete tank, from which it may be pumped into a tank wagon and sprayed on the fields. This system has not been generally adopted, however, as it requires extra labor; and the most common method is to keep the gutter drain plugged with a tight cover and use bedding enough to absorb the liquid manure.

After the manure has been removed from the gutter the plug is removed from the drain and the floors and gutters washed off with a hose. In this way, practically no loss of manure occurs, and nothing but the wash water goes into the sewer system.

Sewer tile under the stable floor should be run in straight lines with a fall of one-fourth inch per foot, and the tile should be carried out from under the building as directly as possible in order that it may be easily cleaned if it becomes stopped up.

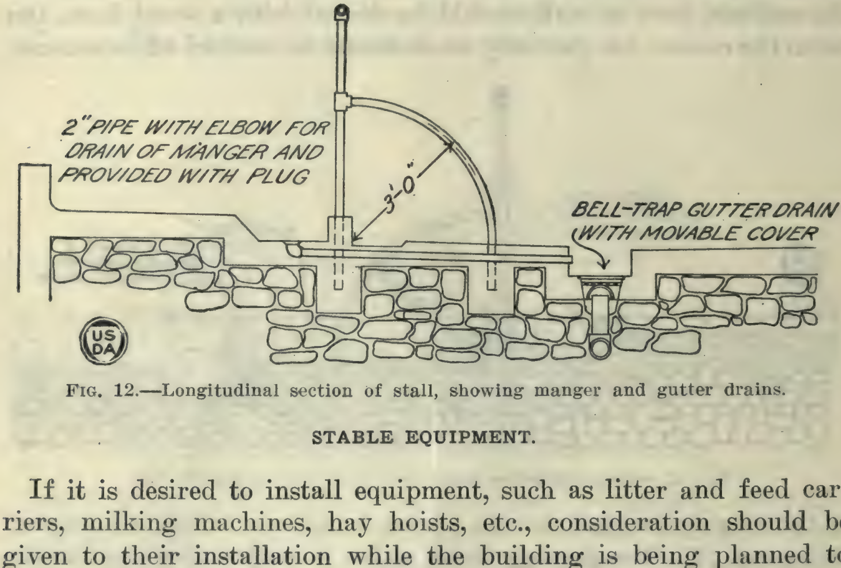
2" PIPE WITH ELBOW FOR DRAIN OF MANGER AND PROVIDED WITH PLUG
3'-0"
BELL-TRAP GUTTER DRAIN WITH MOVABLE COVER
US DA

Fig. 12.—Longitudinal section of stall, showing manger and gutter drains.

STABLE EQUIPMENT.

If it is desired to install equipment, such as litter and feed carriers, milking machines, hay hoists, etc., consideration should be given to their installation while the building is being planned to avoid unnecessary cutting and fitting to erect the equipment.

WATER SUPPLY.

An ample supply of good water is a necessity on the dairy farm, and is highly essential in the dairy barn. There are several methods of watering the cows. Some dairymen prefer to water their cows at a watering trough outside, even in winter, employing heaters to bring the water to the proper temperature before permitting the cows to drink. Others advocate individual drinking cups attached to the stalls in order that the cows may drink whenever they like. Each system has certain merits, but the really important point is to see that plenty of water is provided both for watering the stock and for flushing the floors.

It is desirable to keep the floors as clean as possible, but the washing process is sometimes carried to extremes, with the result that the floors are always wet. This condition is unhealthful. It should be remembered that floors will not dry so quickly in cold weather as in warm weather, and the cows should not be made to lie on a wet floor, even though heavily bedded.

TYPES OF DAIRY BARNS.

THE ONE-STORY COW STABLE.

The more important features common to most dairy barns having been mentioned, the two types of barns in general use will be described.

The floor plan of a one-story cow barn for 20 cows is shown in Figure 4. This barn may be arranged with the cows facing toward the center or toward the side walls, as preferred. If the cows face out, the width of the barn need be only 34 feet outside measurement, while if the cows face in, the barn should be 36 feet wide, as otherwise the alleys behind the cows will be too narrow and the walls will be continually spattered and soiled. The dimensions across the building for a barn 34 feet wide and for one 36 feet wide are shown in Figure 13. The width of side alleys and length of cow stalls are omitted, as they vary in accordance with the length of cow stall selected.

The length of the building may be made to suit the size of the herd, but it is not considered good practice to put more than 50 or 60 cows in one building. In larger herds a better plan is to have several barns. This makes it possible to do the milking at a different time from the feeding and cleaning, in each successive barn. In barns containing more than 30 cows it is advisable to have a cross alley at the middle as well as at the ends. With 30 cows or less the end alleys will be sufficient. Cross alleys should be from 3 feet 6 inches to 4 feet wide.

The walls of the barn may be of stone, brick, tile, concrete, or frame construction; but if of stone, brick, or concrete an air space should be provided within the wall; otherwise the walls will be wet or frosted from condensed moisture.

Figure 5 (p. 6) shows a good type of roof construction for the one-story stable. In this stable no supporting posts or exposed framing are required, and the shape of the ceiling tends to eliminate dead-air pockets where moisture might condense. The natural circulation sweeps across the ceiling toward the outlet flues of the ventilating system.

The floor should be rounded or "coved" against the walls. These coved angles are much easier to keep clean than square angles between floor and wall.

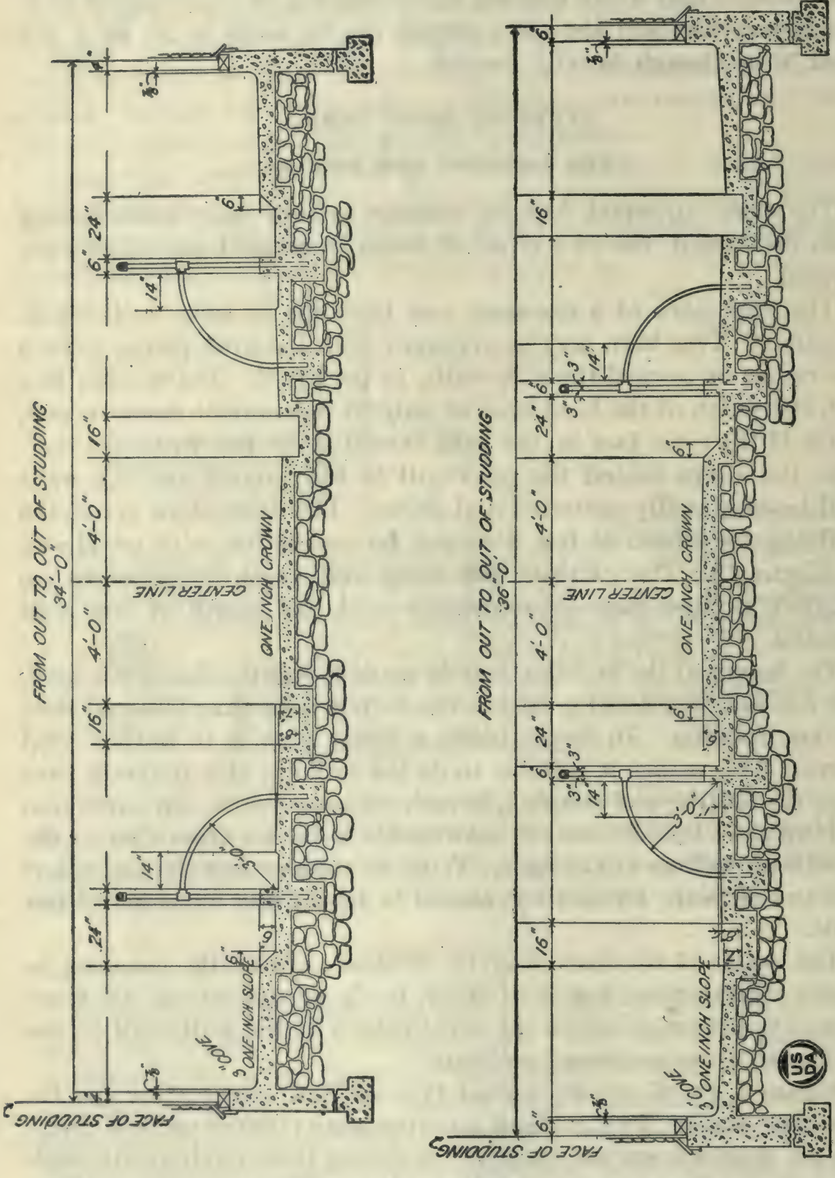

FIG. 13.—Cross sections of stables with cows facing out and cows facing in.

The barn shown in Figure 4 is intended only for stabling the cows and requires a separate building for feed. Figure 14 shows a general plan of this barn in connection with the feed barn, milk house,

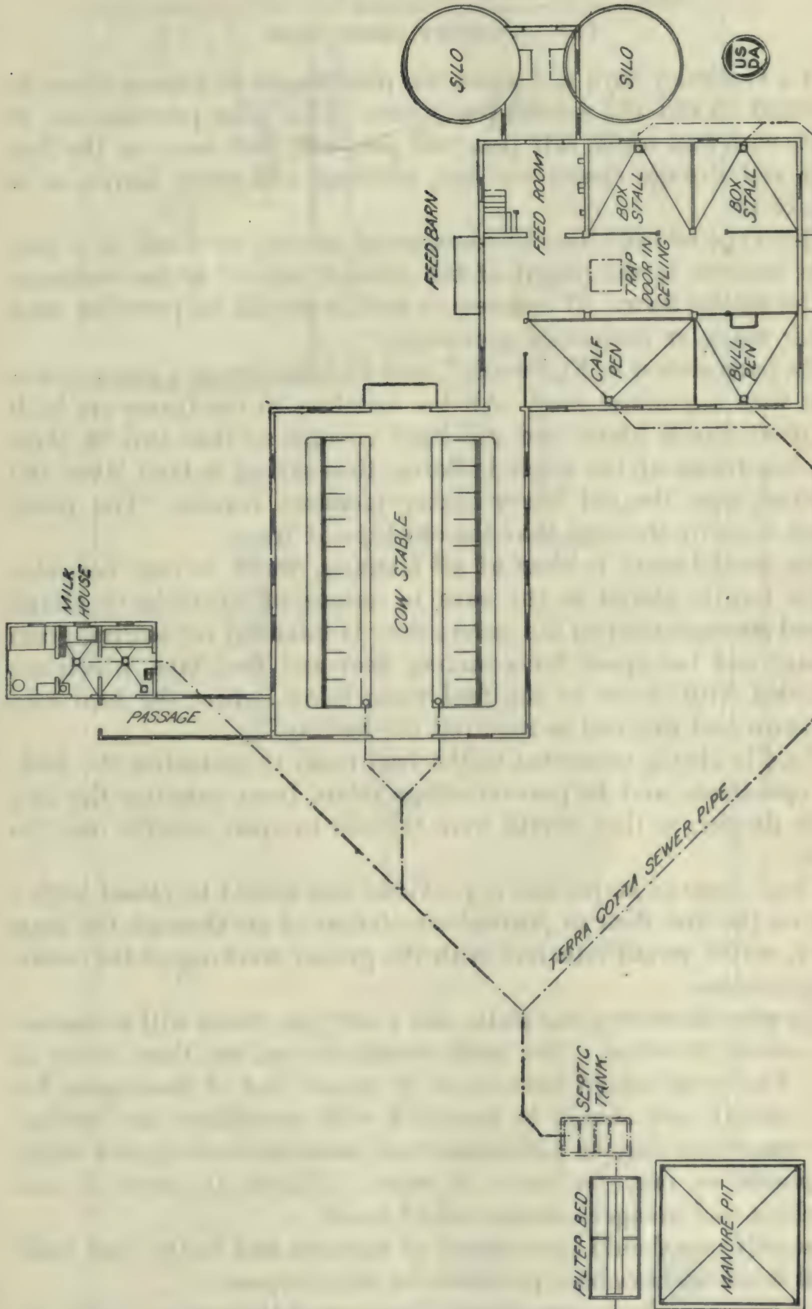

FIG. 14.—General arrangement of one-story stable, silos, milk house, and drainage system.

and silo. The plan also shows a manure pit and septic tank, both of which are desirable adjuncts to a well-kept dairy.

THE TWO-STORY DAIRY BARN.

If a two-story barn is desired, the plan shown in Figure 6 may be modified to suit the special conditions. This plan provides for 20 cows, with box stalls, calf pen, bull pen, and feed room on the first floor and storage spaces for hay, bedding, and grain above, as in Figure 15.

This type of barn may be constructed entirely of wood, or it may have concrete to the height of the window sills or to the underside of the second floor. If concrete is used it should be provided with an air space, as mentioned previously.

The barn shown in Figures 6, 7, and 15 is known as a plank-frame barn with a gambrel roof. All the members in the frame are built up from 2-inch plank and are light enough so that two or three men can frame up the whole building, thus saving in both labor and material over the old heavy-timber mortised frames. The plank frame is really stronger than the old type of frame.

The second story is clear of all framing, which is very desirable where hay is placed in the barn by means of hayforks or slings. A feed-storage room on the second floor is intended for storing grain in bags and has space for a mixing floor and feed bins, which are provided with chutes to the feed room below, where the feed may be drawn and weighed as required for feeding.

The silo also is connected to the feed room to centralize the feeding operations and to prevent silage odors from entering the cow stable proper, as they would were the silo to open directly into the stable.

A hay chute of ample size is provided and should be closed with a door on the first floor to prevent circulation of air through the mow above, which would interfere with the proper working of the ventilating system.

The plan shows two box stalls, and a calf pen which will accommodate about 10 calves. Box stalls should be not less than 10 by 12 feet. Calf pens should have about 30 square feet of floor space for each animal, and should be provided with stanchions for feeding. Calf stanchions may be purchased from manufacturers of cow-stable equipment or may be made of wood. Figure 16 shows a calf stanchion and manger constructed of wood.

The calf pen should have plenty of sunlight and in the plan additional windows have been provided for this purpose.

In a two-story barn cows should face toward the center, so that the posts supporting the second floor may be placed in line with the

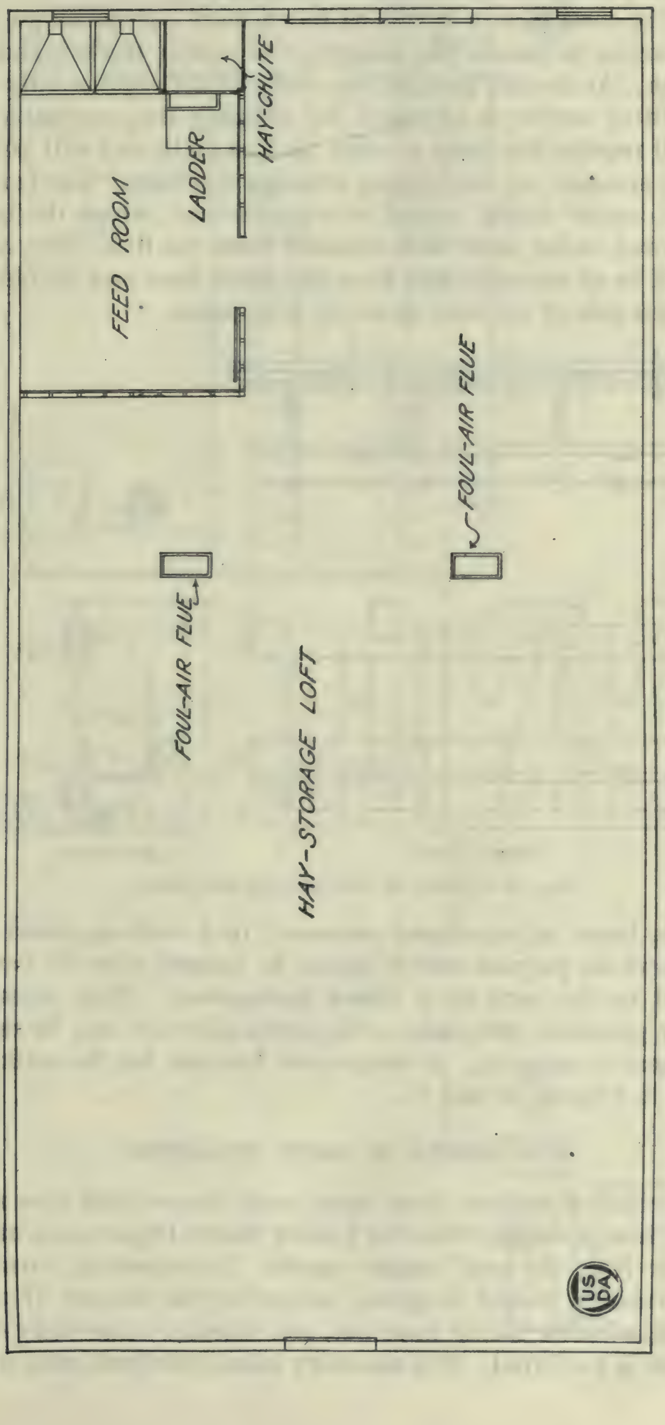

Fig. 15.—Second-story plan, two-story barn.

stanchions, whereas if the cows face out the posts will come near the back of the stalls, where they are more in the way.

When the cows face in it will be found more convenient to install a litter carrier to handle the manure; the carrier track is indicated in the plan. As the calf pen and box stalls do not require daily cleaning, the litter carrier is arranged for cleaning the cow stable only, for it will require less labor to clean the box stalls and calf pen with a manure spreader or cart driven through the barn. The track for the litter carrier should extend to a manure pit, where the manure can be stored under cover and screened from the flies. The manure pit should be at least 100 feet from the dairy barn and should be on the opposite side of the barn from the milk house.

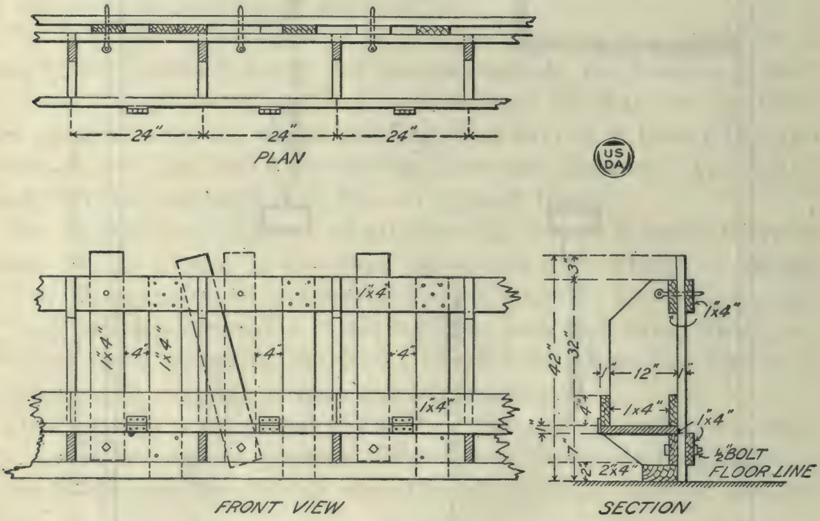

FIG. 16.—Details of calf stanchion and manger.

A milk house is considered necessary in a well-regulated dairy, and to serve its purpose best it should be located near the barn and connected to the barn by a closed passageway. This passageway should be provided with sash on the south side that may be replaced with screens in summer. A convenient location for the milk house is shown in Figures 14 and 17.

BLUE PRINTS OF DAIRY BUILDINGS.

Blue prints of various dairy barns, milk houses, and silos may be obtained free of charge from the United States Department of Agriculture or from the local county agents. In requesting barn plans, full information should be given, indicating the number of cows to be housed, whether facing in or out, and whether a one-story or two-story barn is preferred. If a one-story barn is desired, state whether

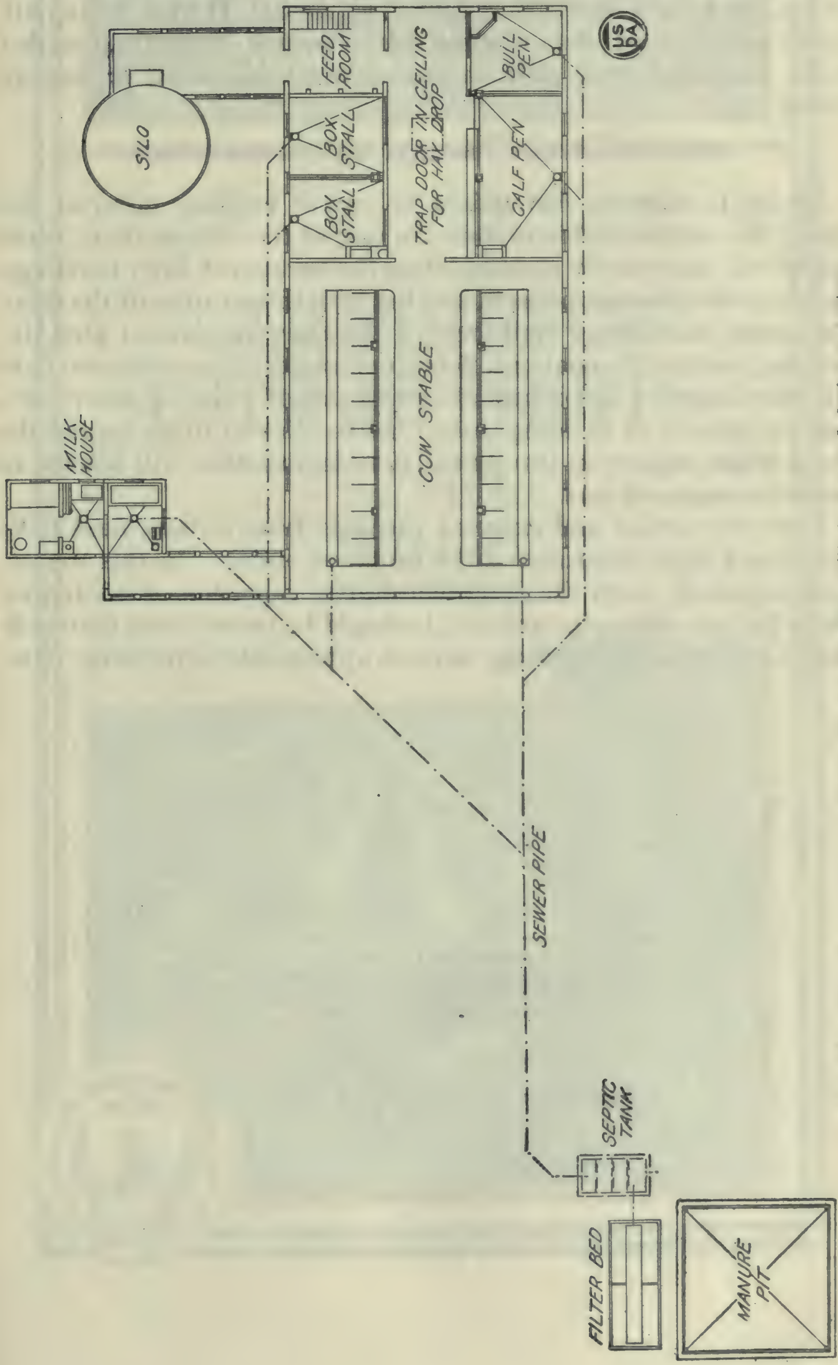

Fig. 17.—General arrangement of two-story barn, silo, milk house, and drainage system.

space is available in present buildings for feed and young stock, and if not, plans for a feed barn should be requested. If plans for a milk house are requested, state whether it is to be used for bottling market milk, handling whole milk in cans, separating cream, or making butter.

CONSIDERATIONS ON COST OF CONSTRUCTION.

Owing to constant fluctuations in cost of building material and labor, it is impracticable to state the cost of the various dairy barns described. Any person contemplating the erection of dairy buildings, however, should select plans in keeping with the earnings of the dairy enterprise conducted. Buildings of the more substantial kind, involving concrete foundations, floors, and sanitary conveniences, have the advantages of less depreciation and also of reducing labor costs, but the expense of building should not be allowed to go beyond the point where interest on investment, plus depreciation, will become an excessive overhead load.

Both the current and expected proceeds from a dairy need to be considered when determining the proposed outlay. In this connection, especially when the dairyman derives a portion of his income from the sale of surplus animals, it should be remembered that well-designed, attractive buildings have an appreciable advertising value.

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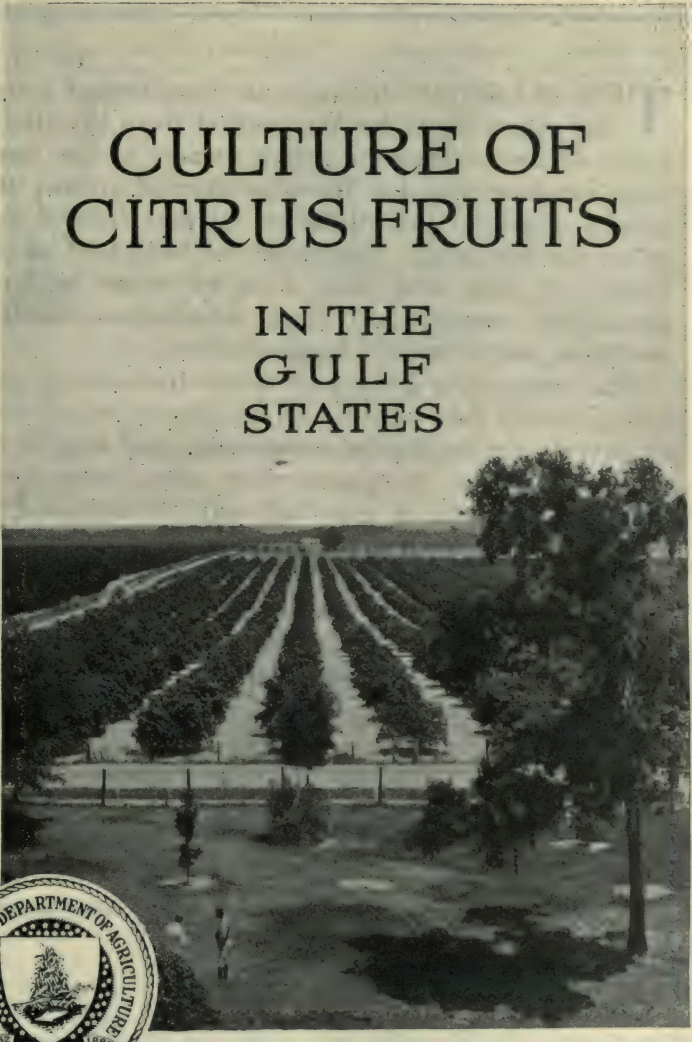
U. S. DEPARTMENT OF
AGRICULTURE
FARMERS' BULLETIN No 1343

CULTURE OF CITRUS FRUITS

IN THE GULF STATES



THIS BULLETIN discusses the business of growing citrus fruits for the market from the standpoint of the prospective grove owner, at the same time summarizing for the experienced grower the results of recent investigations on pest control and grove management. Emphasis has been laid on the choice of sites and soils with reference to frost protection, variety and stock adaptation, cultural methods, and economy in production.

The prospective grower of citrus fruits is advised that personal investigation on the ground in advance of investment is always economical and may avert serious loss and disappointment, since areas quite worthless for citrus growing may lie adjacent to some of the best citrus developments.

The growing of citrus fruits of such excellence as to command a ready market is a highly complex business. Skill, energy, and attention to details are requisites for the successful grower, whether a beginner or one already having some experience in citriculture.

Washington, D. C. July, 1923

CULTURE OF CITRUS FRUITS IN THE GULF STATES.[1]

By E. D. Vosbury, *formerly Scientific Assistant, Office of Horticultural and Pomological Investigations, and* T. Ralph Robinson, *Crop Physiologist, Office of Crop Physiology and Breeding Investigations, Bureau of Plant Industry.*

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SCOPE OF THE WORK.

THERE is an increasing demand, especially on the part of newcomers and prospective growers, for information concerning citrus-fruit growing in the Gulf States. While it is not feasible in this bulletin to give complete information regarding such a complex industry as modern citrus culture, it will be of value to outline some of the general principles as a guide to those interested.

As Florida produces by far the most citrus fruits of all the States under consideration, a more complete discussion is given of the industry in that State than for the other sections. Much of the information relative to Florida, however, will be applicable to the other Gulf States as well. Whenever marked differences in methods exist, each locality is considered separately.

HISTORY OF THE FLORIDA CITRUS INDUSTRY.

Oranges, grapefruit, and other citrus fruits were first brought to the United States by the Spaniards, who planted them in Florida more than three centuries ago. Prior to 1870 the commercial citrus crop of Florida was limited to the output of a few small groves in the northern part of the State. Most of the groves were situated along the banks of the St. Johns and other rivers, as practically the sole means of transportation was by river boats. The methods of culture, harvesting, and shipping were very crude, but in spite of many handicaps the pioneer growers prospered, and after the advent of the railroad lines in the early sixties the industry grew very rapidly. Most of these early plantings were of orange trees. Grapefruit culture was neglected, and the fruit had little market value until the late eighties, when it began to grow very rapidly in favor, until at the present time the grapefruit is becoming a close rival to the orange in commercial importance.

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[1] This publication is a revision of and supersedes Farmers' Bulletin 1122, Citrus-Fruit Growing in the Gulf States.

The first severe freeze recorded was in 1835, when orange trees from 40 to 50 years old were killed at St. Augustine and Mandarin. No freeze since that time has been so severe.

The second serious check to the growth of the industry occurred in 1886, when a severe freeze ruined most of the orange crop and killed many young trees. In the winter of 1894–95 [2] two disastrous freezes killed most of the trees to the ground and ruined thousands of groves. In 1899 another killing freeze occurred. As a result of these costly experiences much of the old northern citrus area was abandoned permanently and the industry was relocated in southern and central Florida. From that date citrus production in Florida increased without any serious check until 1917, when a freeze in February in many sections killed to the ground most of the young trees, frosted most of the crop remaining on the trees at the time, and in some sections cut back the bearing trees severely.

Although the citrus industry has fully recovered from these disasters, the various freezes have taught the growers many valuable though costly lessons. The importance of selecting grove sites which are relatively free from frosts has been strongly emphasized, and the advisability of protecting groves by some means of orchard heating has been demonstrated, particularly in those sections where killing frosts have been experienced. The importance of crop diversity has also been recognized, and many growers who formerly produced citrus fruits exclusively are now raising livestock, truck, forage crops, and other staple farm produce in sections where soil conditions permit.

One-crop farming at best is a gamble, and in case of a severe freeze the man with a number of staple farm crops is much better prepared to weather the lean years than the grower who has oranges only. Furthermore, in diversified farming the labor, horses, and equipment are more efficiently and economically employed through the year than where nothing but a citrus crop is produced. Exception may be noted in the case of citrus regions particularly well located for frost protection and where soil conditions, as in the sandy-ridge section of Florida, are not favorable to crop diversity.

As a result of these experiences the Florida citrus industry is now on a more stable basis than at any time in the past. Great improvements have been made in cultural methods and in the control of insects and diseases. The introduction of modern methods of harvesting, packing, and shipping has stimulated both production and demand by enabling the fruit to be shipped to the most distant markets with a minimum loss from decay.

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[2] Webber, H. J. The two freezes of 1894–95 in Florida, and what they teach. U. S. Dept. Agr. Yearbook, 1895, pp. 159–174, figs. 16–22, pl. 3. 1896.

Four distinct citrus-growing sections of Florida have been outlined,[3] as follows:

Northwestern Florida, that part of the State lying west of the Aucilla River; eastern Florida, that part between the Aucilla River and a straight line drawn from the mouth of the St. Johns River to Cedar Keys; central Florida, that part of the State between the line referred to above and north of the counties constituting southern Florida; southern Florida, the counties of Brevard, Dade, Monroe, Lee, De Soto, Manatee, St. Lucie, and Palm Beach.

By far the greater portion of the citrus fruits are produced in the central and southern sections of Florida. In the western and eastern sections of northern Florida the citrus industry is of relatively minor importance, although there are a number of small, isolated groves, and in the northwestern part of the State plantings of Satsuma oranges have been made in the last few years.

One of the most important factors in raising the standard of citrus growing in Florida has been the Florida Citrus Exchange, a nonprofit, cooperative marketing organization which includes growers in all parts of the State. The Florida State Horticultural Society has also been a valuable agency in promoting the social and business relations of the citrus growers.

HISTORY OF THE CITRUS INDUSTRY IN THE OTHER GULF STATES.

In a narrow area on either side of the Mississippi River south of New Orleans, in Louisiana, citrus fruits have been grown for many years. This region has experienced occasional setbacks from frosts and other causes, but citrus fruits are still grown there commercially on a small scale. Most of the crop is sold in the New Orleans market.

Extensive plantings of Satsuma oranges and other citrus fruits have been made in other sections of southern Louisiana. The losses from killing frosts have been so heavy, however, that most of these plantings have been abandoned. Many experienced Louisiana growers believe that citrus planting, except in the region south of New Orleans, should be restricted to small groves in the most frost-free localities. A number of such small groves of Satsuma oranges have been found profitable in the production of fruit for the local markets. Usually these groves consist of an acre or two of fruit, planted on protected sites on southern Louisiana farms where general farming is practiced.

The commercial planting of citrus fruits in Texas is now restricted almost entirely to the lower Rio Grande Valley, where several thousand acres are planted under irrigation, water being pumped from the Rio Grande River. Grapefruit constitutes about three-fourths of the present acreage, the remainder being about equally divided between oranges and lemons. Commercial shipments on a car-lot basis were commenced in 1921–22, and the distribution thus far has been limited to near-by cities.

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[3] Catalogue of fruits. *In* Proc. 18th Ann. Meeting, Fla. State Hort. Soc., 1905, pp. i–xxii. 1905.

Considerable loss has been experienced in the past from the freezing of young trees, and some form of frost protection is considered necessary. Owing to the tendency for seepage water from irrigation canals to accumulate in low spots with consequent water-logging and rise of alkali, many plantings on undrained locations have suffered. The acreage already planted is ample to determine in due time whether this section of Texas is suitable for commercial citrus culture. Furthermore, until storage systems for irrigation are developed to safeguard both the quantity and quality of the water available, it would seem hazardous to extend citrus plantings further, particularly as the acreage of orchard crops can not be regulated to accommodate the supply of water, as with ordinary field crops. Citrus fruits should be grown as one crop in a scheme of general or diversified farming rather than as a single-crop venture.

Satsuma oranges and other citrus fruits were at one time extensively planted along the northern Gulf coast section of Texas, particularly in the vicinity of Houston and Beaumont. Many of these plantings were repeatedly killed back by cold, and in the winter of 1916–17 thousands of acres of citrus groves were frozen to the ground and abandoned. On account of unfavorable climatic conditions and other factors, as pointed out by the United States Department of Agriculture in past reports,[4] the Gulf coast of Texas is not in general a promising section for the profitable and conservative development of an extensive citrus industry. Future plantings north of the Rio Grande Valley should be limited to small groves of the hardier sorts of citrus fruits, such as Satsuma oranges and tangerines, planted in the most favorable localities to produce fruit for the home or local markets.

In Alabama the main citrus sections are located in Mobile and Baldwin Counties. In Mississippi there are smaller commercial plantings along the Gulf coast. These plantings consist almost entirely of Satsuma orange trees, although a few round oranges and grapefruit are grown for home use. The industry in this section received a severe check in the heavy freezes of the winter of 1916–17, when hundreds of acres of groves were cut back or killed. As a result of this freeze and a number of previous freezes, Mississippi and Alabama growers have come to the same conclusion as the Florida growers, namely, that groves should be located on the most frost-free sites, and for the greatest degree of safety the grower here, as in most other localities, should make citrus culture a part of general farming rather than a single-crop venture.

These setbacks and their lessons to the growers have placed the Satsuma orange industry in Alabama and Mississippi on a much safer basis than in earlier years. A cooperative association of the growers, known as the Gulf Coast Citrus Exchange, has been of much assistance in the development of the marketing end of the industry in that section. The Gulf Coast Horticultural Society fills the same place with reference to the citrus industry in northwestern Florida, southern Alabama, and southern Mississippi as does the Florida State Horticultural Society for the main citrus sections of Florida.

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[4] Agricultural conditions in southern Texas. U. S. Dept. Agr., Bur. Plant Indus. [Misc. Pub.] 457, 8 pp. 1909.

Small home orchards, including the Satsuma and round oranges and occasionally a few lemon and grapefruit trees, are found in many Gulf State sections too cold for larger commercial plantings. A few very small groves have been planted in southern Georgia and on the islands off the coasts of Georgia and South Carolina. In these colder sections citrus plantings are confined to trees budded on trifoliate-orange stock and grown in sheltered dooryards and similar spots where they can be protected in winter.

The principal areas within which citrus fruits are grown are shown in Figure 1.

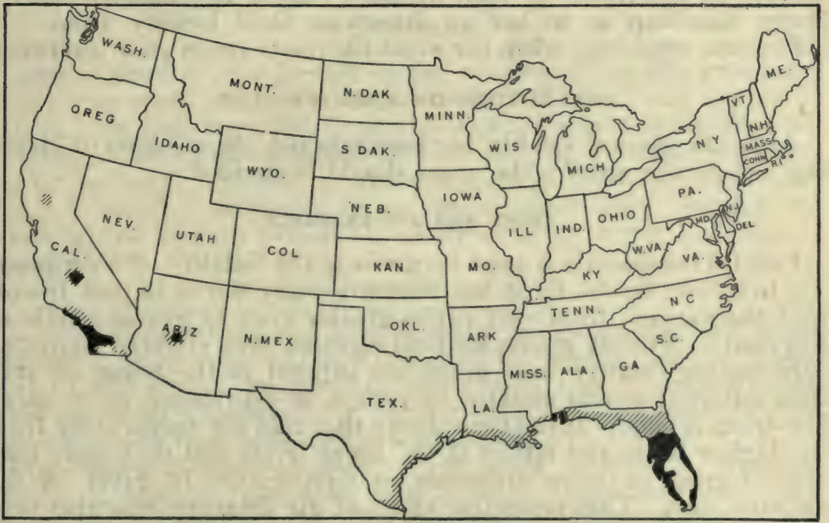

FIG. 1.—Outline map of the United States, showing the principal regions in which citrus fruits are grown commercially. The shaded areas show the regions where citrus fruits are grown. The heavily shaded areas show important commercial citrus sections.

SELECTION OF A LOCALITY AND SITE FOR A GROVE.

CHOOSING A GENERAL LOCALITY.

The first problem to be solved by the prospective citrus grower is the selection of a general locality and a particular site in that locality for planting the grove. It is quite impossible to answer the questions so frequently asked regarding the advantages of one locality compared with another. Each section has its particular advantages and drawbacks, and one investor will prefer conditions to which another would strongly object. Prospective growers should therefore make as thorough and careful an investigation as possible, especially when the amount of capital available is limited. The various State agricultural experiment stations will gladly advise prospective settlers as to sites, and in many cases they can put newcomers in touch with experienced, successful citrus growers from whom valuable information can be secured. It is inadvisable to purchase lands for agricultural purposes without first making a careful personal investigation of the locality, especially when such a large investment is involved as is necessary in the development of a citrus grove.

The general advantages of any locality for a farm home, including sanitary conditions, nearness to good schools, neighbors, roads, and other factors, should be fully considered. Due emphasis should be placed on the record of any locality as to damage from killing frosts in the past. In general, growers should restrict extensive plantings to established and prosperous communities which have a long record for the extensive and profitable production of high-quality fruit.

It is a great advantage to be located near a shipping point and close to a packing house with a high reputation for the quality of its output. Long wagon hauls are expensive and impair the shipping quality of the fruit. A haul of more than a few miles is such a heavy handicap as to bar an otherwise ideal locality from consideration, especially when the available roads are in poor condition.

SELECTION OF A GROVE SITE.

After the general locality has been selected, the question of choosing a particular site for the grove should be decided.

FROST AND AIR DRAINAGE.

Careful consideration must be given to the liability of a proposed site to killing frosts, for it has been strikingly shown in past freezes that the damage from cold varies greatly even in groves a mile or less apart. Florida groves on land elevated even slightly above the surrounding country were much less injured in the freeze of 1917 than adjacent groves situated in valleys or depressions or on other low-lying ground. It has been shown that cold air drains away from the higher lands and settles in the lower levels and that there may be 5 degrees or more difference in temperature in favor of the elevated sites. This protective effect of air drianage was also very marked in the orange sections of Alabama, as well as in the other Gulf States, following the freezes of the winter of 1916–17.[5] Groves on low lands and in depressions generally were badly frozen back, while those on higher lands in the immediate vicinity escaped with much less injury. One of the Alabama growers remarked that the freezes had had one benefit, " They have shown us where not to plant."

SOIL DRAINAGE.

Land slightly elevated has another great advantage over low land and hollows, aside from that of greater freedom from frost, namely, that of better soil drainage. Good soil drainage is an essential factor, and land subject to overflow or land where the water table stands less than 3 or 4 feet from the surface at any season of the year should be avoided unless this defect can be remedied by artificial drainage.

FROST PROTECTION AFFORDED BY BODIES OF WATER.

Lakes, bays, and other bodies of water may afford valuable protection from frost, particularly when they are of considerable size.

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[5] Winberg, O. F. E., Starcher, G. C., and Isbell, C. L. Report on freeze injury to citrus trees for 1916 and 1917, with notes on orange culture in south Alabama. Ala. Agr. Expt. Sta. Bul. 199, 26 pp., 7 pl. 1918.

This protective influence of water, however, is limited almost entirely to groves on the leeward side of the water bodies and is seldom noticeable for a distance of more than a mile or so from the shore. In the freeze of 1917 groves on the southern shore of Lake Apopka, Fla., a circular body of water about 25 miles in diameter, suffered very little injury, although groves 2 miles farther south were severely cut back. In this instance the freezing winds came from the northwest, and only the groves on the south and southeastern, or leeward, shores received noticeable protection. In the case of very large bodies of water, such as the Gulf of Mexico, the protection afforded is much more extensive.

WINDBREAKS.

Belts of timber, when located on the windward side of a grove, are valuable as windbreaks and often protect the trees from drying as well as from freezing winds. On the leeward side of the grove such windbreaks are of no value and may actually be a detriment, checking air drainage. Where the grove is entirely surrounded by dense woods it is often advisable to cut one or more lanes through the woods on the leeward side of the grove so as to permit the cold air to drain away.

SOILS.

Although citrus trees will grow in many soils, they are much better adapted to some soils than to others, and the selection of the proper kind of soil should be carefully considered. In Florida the soil types used most extensively for citrus groves are known as high pine, flatwoods, high hammock, and low hammock.

Low-hammock soils in their virgin state support a luxuriant growth of cabbage palmettos, oaks, bays, or other hardwood trees. They are the richest of the four soil types in fertility and humus, and while expensive to clear they make splendid citrus soils if well drained.

High-hammock lands have a higher elevation and a more open growth of hardwood trees than low-hammock lands. They are fertile and well drained, and many growers consider them the most desirable of all citrus soils. In general, these hammock soils require much less fertilizer than the lighter pineland soils.

Most of the recent citrus plantings in Florida have been made on high pineland, three grades of which are recognized. The best grade is characterized by large straight-growing pines with occasional oaks, hickories, or other hardwood trees. The soil is a sandy loam, fairly rich in humus, and is underlain with a clay subsoil at a depth of 6 feet or less. In second-grade pinelands the pine trees are smaller and there are few or no hardwoods, while the subsoil is farther from the surface. In the third or poorer grade the pines are still smaller and scrubbier and the clay subsoil far below the surface soil.

The high pinelands as a class are well drained and relatively inexpensive to clear. The better grades, while not high in fertility, make good citrus lands if the humus supply is adequately maintained.

Flatwoods pineland is usually low and uniform in elevation. The soil is often rich in humus, and where such land can be adequately drained it may be well adapted to citrus culture. Many flatwoods areas, however, are poorly drained or subject to overflow. Frequently they are underlain with a layer of hardpan. Such soils are of very inferior value for citrus trees and should be avoided. A dense growth of saw palmettos in pine flatwoods is frequently an indication of an undesirable hardpan or subsoil.

The several soil types described for Florida are also found in some of the other Gulf States. In Louisiana, south of New Orleans, the soil is of a rich alluvial character and is frequently subject to overflow from the Mississippi River, so that high dikes are often necessary to keep the water from injuring the groves.

In the Rio Grande Valley of Texas the soils are of a silty formation. In southern Alabama and Mississippi well-drained hammock lands and the more fertile type of pinelands are preferred for citrus plantings. The best types contain considerable humus and have a clay subsoil within 2 or 3 feet of the surface.

KINDS OF CITRUS FRUITS FOR THE GULF STATES.

RELATIVE IMPORTANCE OF THE CITRUS FRUITS GROWN.

After the locality and site have been selected the next problem is that of choosing the best kinds and varieties of citrus trees for planting. The most important citrus fruit grown in Florida is the common round sweet orange, which is produced in all the citrus sections of the State. Round oranges are also grown commercially in the Delta region of New Orleans.

Grapefruit ranks next to the round orange in importance (fig. 2). The trees are less hardy than the orange, and extensive plantings are found only in central and southern Florida, although there are a few grapefruit groves in the orange sections of Louisiana and Texas and scattered trees in the other Gulf State citrus sections.

The Satsuma orange and the tangerine rank next to grapefruit in importance. Satsuma oranges are the most important of the citrus fruits grown in northwestern Florida, southern Mississippi, southern Alabama, and other sections too cold for round oranges and grapefruit. Although the Satsuma orange when budded on trifoliate stock is considerably hardier than the round orange, it is by no means "frost proof," and it should be planted only on the more frost-free sites of the sections where it has already proved successful. In southern Florida the Satsuma orange is of unsatisfactory quality and is seldom planted. The tangerine is grown most extensively in southern and central Florida, but it is also raised in all the citrus sections of the Gulf States. It is almost or quite as hardy as the Satsuma orange when grown on the same stock.

Lemons are much more tender than oranges and should be planted commercially only in the warmest sections. Prior to the great freeze of 1895, which killed most of the trees, many thousands of boxes of lemons were shipped from Florida, but now there are no large commercial lemon groves in the Gulf States, although numerous lemon trees are grown in dooryards throughout southern Florida. It is possible that lemon culture could be extended in the most protected regions of extreme southern Florida, such as the coastal regions south of Fort Pierce and Punta Gorda, to the point of producing sufficient fruit for the local markets.

Limes are still more tender than lemons, and their commercial culture is restricted to the Florida keys and to a few of the best-protected localities of southern Florida. For home use limes are often grown in sheltered dooryards much farther north. The demand for limes is much greater than the supply, and their culture in favorable localities of southern Florida, such as on the keys and in the coastal regions mentioned, promises good returns.

The kumquat is a small tree or bush which bears abundant round or egg-shaped fruit the size of small plums. It is hardy, makes a handsome ornamental, and is popular as a dooryard shrub in all the Gulf coast sections. The fruit is grown to a small extent commercially and shipped to the North as fancy fruit for the holiday trade. In the vicinity of Mobile and in a few other sections kumquats are grown for marmalade and other preserves.

Citrons, shaddocks, and a number of other citrus fruits are occasionally grown as ornamentals in Florida and the Gulf coast sections.

Tables 1 and 2 from the United States census report for 1920 show the relative importance of the citrus fruits grown in the Gulf Coast States in 1919.

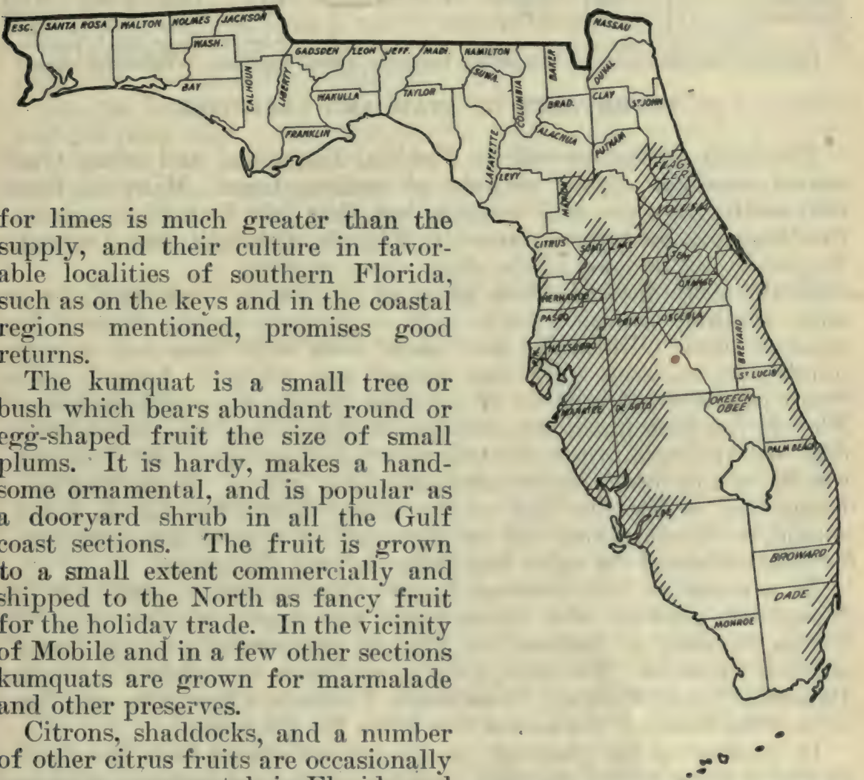

FIG. 2.—Map of Florida, showing, by shading, the location of the principal regions within which round oranges and grapefruit are grown.

TABLE 1.—*Principal citrus fruits grown in Florida, 1919.*

Fruit.	Bearing trees.	Nonbearing trees.	Boxes.	Value.
Orange	3,645,811	2,311,571	5,930,422	$15,715,618
Grapefruit	1,681,481	963,336	3,158,431	6,158,941
Limes	115,624	80,870	27,725	97,040
Tangerines	38,516	29,770	67,475	236,170
Lemons	34,176	22,756	31,204	93,612

TABLE 2.—*Citrus fruit trees (bearing and nonbearing) in Alabama, Mississippi, Louisiana, and Texas, 1919.*

Fruit.	Alabama.		Mississippi.		Louisiana.		Texas.	
	Bearing trees.	Nonbearing trees.	Bearing trees.	Nonbearing trees.	Bearing trees.	Nonbearing trees.	Bearing trees.	Nonbearing trees.
Orange	[1] 260,294	[1] 165,536	[1] 28,127	[1] 37,350	104,382	26,356	14,331	41,329
Grapefruit	587	1,337	571	944	405	727	5,454	74,039
Miscellaneous	[2] 2,969	[2] 469	....	....	....	....	[3] 1,385	[3] 8,383

[1] Principally Satsuma oranges. [2] Tangerines, kumquats, lemons, and limes. [3] Principally lemons.

IMPORTANCE OF STANDARD VARIETIES.

The early citrus groves in Florida, Louisiana, and other Gulf States consisted almost entirely of seedling trees. Many of these old seedling groves still remain, but they are fast disappearing. Seedlings are no longer planted in Florida, although they are quite frequently set in some of the other citrus sections.

In the early days of citrus growing in Florida there were one or more seedling orange trees in each community locally famous for superior fruit. Budwood was taken from such trees and a large number of varieties were thus named and planted. Largely as a result of the great number of varieties grown, the citrus output of Florida has been much less uniform in appearance and quality than that of California, where but two varieties of oranges—the Washington Navel and the Valencia—are extensively grown. It has long been recognized in Florida that of the many varieties available a few should be chosen which can be developed as typical standard commercial sorts and the other less desirable ones eliminated.

As a result of this demand for standardization, a committee of prominent growers and nurserymen was appointed by the 1916 Citrus Seminar at Gainesville, Fla., to recommend a short list of selected varieties. The orange varieties chosen as standard were the Parson (*Parson Brown*), Homosassa, Valencia, Pineapple, and Lue (*Lue Gim Gong*). No action was taken for grapefruit.

In making up his planting list the grower should limit his choice to two or three of the standard varieties of oranges best suited to his special requirements of soil, season, and situation. For each locality there are certain varieties which are best adapted. The Parson orange, for example, matures earlier and colors up more fully in the hammock sections of north-central Florida than in localities farther south. The Valencia variety, on the other hand, is less desirable for northern Florida, as, on account of its late season of ripening, crops are frequently lost by frosts. The grower should take into careful consideration the matter of varietal adaptability before making out his planting list. The same course should be taken with grapefruit, although there is less varietal distinction with grapefruit than with oranges.

In southern and central Florida many experienced growers diversify their citrus plantings and are setting out two or three standard varieties of oranges, three or four of grapefruit, and one of tangerines. A few growers are planting oranges or grapefruit, or even tangerines, exclusively, but it is believed that the practice of growing some of each kind will be the safest and most profitable in the long run. In the colder citrus sections there is less opportunity for such diversity, as the choice must be limited to the hardier sorts and those maturing early.

HOME-GROWN VARIETIES.

Every home in the citrus region of the Gulf States should have its own supply of fruit from a small grove or dooryard planting. With a little care the trees can be made to give returns in pleasure and in good fruit far exceeding their cost.

For the home orchard a much wider choice of varieties is possible and desirable than for the commercial grove. The ideal to work for in planning the home planting is a succession of high-quality fruit throughout as long a season as possible. Very often fruits too tender for commercial planting in the locality can be successfully grown in the dooryard by giving them some winter protection.

VARIETIES OF CITRUS FRUITS FOR THE GULF STATES.

VARIETIES OF ROUND ORANGES.

The Parson (*Parson Brown*) is the earliest commercial variety grown in Florida. Its season is from early October to November, and the fruit is often sweet enough to ship while the skin still shows considerable green color. The fruit is medium in size and oblong in form, with a fine-textured peel. The dessert quality is fair to good when grown under the most favorable conditions. It does best when grown on sour-orange stock in hammock soil, while on rough-lemon stock, when planted in light soil, it is usually dry and poor. Many growers in northern Florida and in other colder citrus sections plant the Parson because it matures before the season of dangerous frosts. Early fruit of other varieties is often shipped and labeled "Parson Brown," but this practice is discredited by all reputable growers. The Parson, while not an ideal sort, is the best known and most widely planted early variety.

The Homosassa variety matures from late November to February. The fruit is round, somewhat flattened, and medium to large in size. The appearance, dessert quality, and shipping quality are excellent. The trees are regular and prolific bearers when given good care. Those who have grown the Homosassa consider it a profitable variety, and it will doubtless be more widely planted in the future, as it replaces in season the old seedling trees now rapidly dying out.

The Pineapple is the leading midseason variety, maturing from late December to early March. It is variable in shape, medium to large in size, with a thin glossy skin of high color and has numerous seeds. It is a good shipper and has high dessert quality when well grown. The tree is prolific and vigorous. The fruit often has a distinct pineapple aroma when mature, from which characteristic the name was doubtless derived. (Fig. 3.)

The Valencia, formerly known in Florida as "Hart's Late" and also as "Tardiff," is the latest standard variety grown. The fruit is slightly oval in shape, of good size, and has a very smooth, tough peel. It ripens in March and April, frequently hanging on the trees late into May.

The Lue (*Lue Gim Gong*) is a late variety of recent origin. It is very similar to the Valencia in size, shape, and other characteristics, but it is claimed that the fruit will hang on the trees even later than that variety. The Lue has been planted rather heavily in Florida during recent years, but is generally marketed as a Valencia.

In addition to the standard varieties mentioned, several other oranges are frequently grown in Florida. The various blood varieties, including the Ruby, Maltese, and St. Michael, are often grown commercially. Although somewhat lacking in vigor, the blood oranges are frequently profitable when grown on fairly strong soils. They are of highest dessert quality and usually bring a premium over other varieties when shipped as fancy fruit. They are especially recommended for home plantings.

FIG. 3.—Grove of oranges of the Pineapple variety at Dunedin, Fla.

Several other old varieties, such as Jaffa, Enterprise (seedless), Drake Star, and Lamb Summer, are grown in certain localities to which they seem especially adapted.

In Louisiana much of the orange crop is picked from seedling trees and shipped as "Louisiana Sweets" or "Creole" oranges. While much of this seedling crop is of high dessert quality, most Louisiana growers now believe that a more uniform and profitable crop can be secured by substituting standard varieties for these miscellaneous sorts. Consequently, recent plantings in Louisiana are largely of the standard Florida varieties, such as the Pineapple and the Parson. Washington Navel oranges on trifoliate-orange stock are grown profitably by some citrus growers in the lower Mississippi Delta section.

In the lower Rio Grande Valley of Texas the more common varieties are the Parson, Washington Navel, Pineapple, and Valencia. The Parson has been locally named "Texas Sugar" and seems well adapted to the Rio Grande sections. The Dancy tangerine and King orange are also finding some favor because of earliness and high color. The Washington Navel is only fairly productive and yields fruit of too large a size to meet trade requirements. In southern Mississippi and Alabama very few round oranges are now planted commercially.

GRAPEFRUIT VARIETIES.

Most grapefruit varieties are less distinct in their characteristics than oranges. A large part of the Florida crop is produced on budded trees of unnamed local sorts. This fruit, together with the product of seedling trees, is popularly designated as "Florida common." The more recent plantings, however, are largely confined to the standard named sorts.

The Hall is a midseason variety maturing in February and March. The dessert quality is good and the trees are prolific. The fruit is frequently borne in clusters, and the variety is often known as Silver Cluster.

The Walters is also a midseason variety which is picked in February and March, and sometimes later. The dessert quality is excellent, although it is sometimes objectionably seedy. The trees are vigorous and prolific. The Walters variety is very similar to the Hall, and they are frequently regarded as identical.

The Marsh (*Marsh Seedless*) variety matures at the same season as the Walters. The dessert quality is good, although the fruit lacks somewhat the characteristic bitter principle of most grapefruit. The fruit is seedless, or nearly so, and this quality is considered of much value.

The Duncan is the standard late-season variety. It matures in Florida from April to May and can sometimes be left on the trees until early June. The dessert quality is excellent, and the trees are vigorous growers, good bearers, and somewhat hardier than other grapefruit varieties.

The McCarthy is another late variety of good dessert quality. The trees are vigorous and prolific. The fruit is borne singly rather than in clusters, as is the case with most other grapefruit varieties.

The Davis (*Davis Seedless*) is a seedless variety which has been quite extensively planted in Dade County, Fla., during the last few years. It has not yet been fully tested, but is considered a promising variety for trial.

The Triumph is one of the earliest of grapefruit varieties, frequently maturing in December. On account of its extreme seediness and small size, however, it can not be recommended for commercial planting, although it is worthy of a place in the home grove.

The Foster, a pink-fleshed variety originating as a bud sport of the Walters, is finding some favor because of its unusual color and early maturity.

In the citrus sections of the Gulf States, aside from those in Florida, the favorite grapefruit varieties are the Duncan, Marsh, Walters, and Foster. The Duncan is well adapted for the colder sections where grapefruit is grown, as the tree is somewhat hardier than the other standard sorts.

VARIETIES OF KID-GLOVE ORANGES.

Because of the ease with which the skin may be separated from the pulp, the tangerine, the Satsuma, and the mandarin are popularly known as kid-glove oranges.

The Satsuma was formerly considered a single distinct variety, but recent investigations indicate that at least six varieties are grown in Japan.[6] Two of these varieties, the Owari and Ikeda, appear to have been introduced into the United States at an early date, and most of the commercial plantings can be referred to one of these two varieties. The Owari is a flat thin-skinned fruit of good quality, maturing early. The Ikeda is inclined to be more spherical in shape, the skin is thicker and coarser in texture, and the season is usually from two to four weeks later than the Owari. For the best production and hardiness trees of both varieties should be planted only on trifoliate-orange stock.[7]

In light sandy soils, especially from central Florida southward, where the trifoliate stock is unsuited, the sweet orange appears to be the next best Satsuma stock commercially available.

The tangerine ranks with the Satsuma as the most important of the kid-glove oranges. The Dancy is the only variety of tangerine grown commercially. Its season is December to March, while the Satsuma varieties mature from October to November.

The King, a large-fruited rough-skinned variety of the kid-glove sort, is grown occasionally as a fancy fruit. It is excellent in dessert quality as grown on hammock soils and other heavy Florida soils suited to the sour-orange stock, but on the light soils of southern Florida it is usually of inferior quality.

LEMON VARIETIES.

Lemons can be grown commercially only in the warm sections of Florida, as the trees may be frosted where the temperature falls below 28° F.

The Lisbon is a favorite variety. In favorable locations the tree is a vigorous grower and usually prolific. Most of the crop matures during the winter months.

The Villafranca is perhaps the most commonly planted of the lemon varieties in Florida. The tree is a vigorous grower, with few thorns, and is usually productive.

The Ponderosa is a valuable variety for the home grove. It is an extremely large sort, the fruits often weighing 2 pounds.

LIME VARIETIES.

The Florida lime crop is gathered almost entirely from seedling trees grown on the keys and in other tropical regions of southern

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[6] Tanaka, Tyozaburo. Varieties of the Satsuma orange group in Japan. U. S. Dept. Agr., Bur. Plant Indus., Off. Crop Physiol. and Breeding Invest. Cir. 5, 10 p., 2 figs. 1918.

[7] Swingle, W. T. The limitation of the Satsuma orange to trifoliate-orange stock. U. S. Dept. Agr., Bur. Plant Indus. Cir. 46, 10 p., 6 fig., 1 pl. 1909.

Florida. The fruits of these seedling trees are quite variable in size and shape and are known commercially as Mexican or key limes. Some ripen every month in the year, but the main crop is harvested in the summer. The propagation of the best types by budding would doubtless lead to the production of larger and finer crops than are secured from the seedling trees commonly planted. (Fig. 4.)

The Tahiti variety is a budded sort that has been planted recently in southern Florida. It is a somewhat stronger grower and a trifle more hardy than the Mexican seedling limes. The tree is vigorous and usually is a prolific bearer. The fruit is similar in size and appearance to a small lemon. It is of excellent quality for home use and may eventually become of commercial importance, although at present the northern trade prefers the smaller key limes.

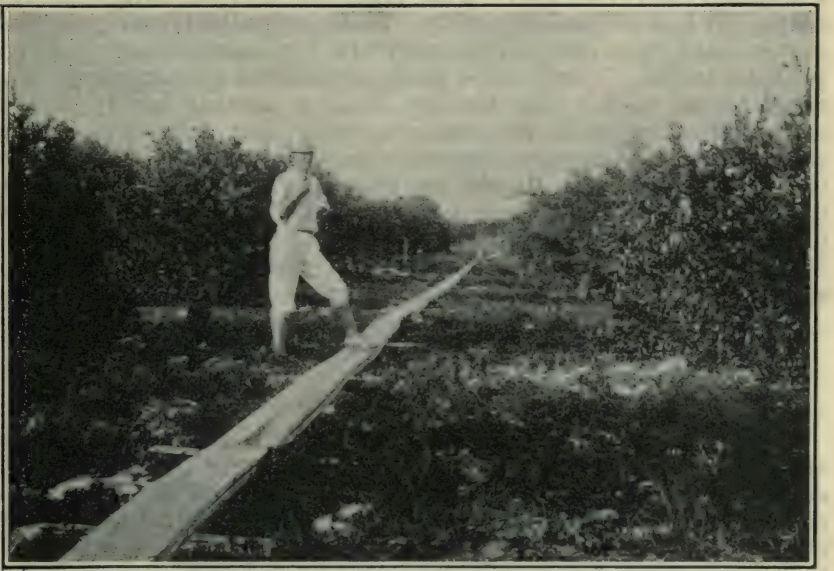

FIG. 4.—A well cared for lime grove at Upper Metacombe Key, Fla.

KUMQUAT VARIETIES.

The varieties of kumquats grown are the Nagami and Marumi. The Marumi bears small spherical fruits, while the Nagami bears larger oval-shaped fruits and is preferred to the Marumi for all commercial planting.

The Meiwa variety recently introduced is of the highest quality for eating in the fresh state. In size it resembles the Nagami, but it is more nearly spherical in shape.

NEW VARIETIES OF CITRUS FRUITS.

A number of interesting new fruits have been originated by the crossing of various citrus parents.[8] Among the most promising of these fruits is the tangelo, a hybrid of the tangerine and grapefruit, the Sampson being the favorite commercial tangelo of this group of hybrids; the Eustis limequat,[9] a hardy cross between the Mexican lime and the kumquat, the fruit of which is much like the lime in character and is produced over a long period of the year; and the citranges, a group of hybrids between the sweet orange and the trifoliate orange, which are of considerable value as hardy substitutes for the lemon and as ornamentals in regions too cold for growing even the hardiest of standard citrus varieties.

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[8] Swingle, W. T., and Robinson, T. R. Tangelos: What they are. The value in Florida of the Sampson and Thornton tangelos. U. S. Dept. Agr., Bur. Plant Indus., Crop Physiol. and Breeding Invest. [Cir.] 4, 3 p. 1918.

New varieties of citrus fruits originating as chance seedlings or bud sports or brought to light by foreign exploration are claiming attention from time to time. The Temple orange is a new variety recently brought to light at Winter Park, Fla. It is characterized by a deep-red color, thin rind, rather large size, and somewhat flattened shape. It is a midseason variety. Some extensive plantings of this orange have been made in recent years, but commercially it is not yet fully tested. It appears to be better adapted to sour-orange than rough-lemon stock. The Golden Ring is another highly colored orange of rather small size, maturing early, that is being planted in some sections. Although new varieties when promising ought to be tested, such new sorts should not be exclusively planted until they have demonstrated by their behavior in a practical test for each locality and soil type that they are superior to existing standard varieties in some leading characteristic, such as season, dessert or shipping quality, or hardiness.

PROPAGATION OF CITRUS TREES.

CITRUS STOCKS.

Citrus trees for planting are usually budded on sour-orange, rough-lemon, and other seedling stocks. The problem of selecting the best stock is of great importance, for in case an unsuitable stock is used the value of the grove may be permanently impaired. Sweet-orange seedling stocks were formerly used very extensively, but as they have been found very susceptible to foot-rot they are now seldom planted.

The sour orange, a hardy species of citrus, which is frequently found growing wild in Florida forests, is the leading stock in Florida as well as in California and most of the citrus-growing regions of the world. It is vigorous and resistant to foot-rot, and the trees produce thin-skinned fruit of fine quality which holds on the branches late in the season. In Florida sour-orange seedlings are the favorite stocks for hammock and flatwoods soils as well as the best grade of pineland. Most growers prefer sour-orange stock wherever soil conditions permit its use.

On light, dry, sandy soils in southern Florida, where sour-orange stock lacks thrift, the rough lemon, a vigorous-growing species of citrus related to the common lemon of commerce, is used. Trees on rough-lemon stocks make a very vigorous growth and on very light soils are easier to care for and require less fertilizer than trees on sour-orange roots. Rough-lemon stocks are tender and not sufficiently hardy for Gulf State sections colder than southern and central Florida. Under favorable conditions trees on rough-lemon stock usually are vigorous and productive, but it is claimed by many growers that the life of such trees is shorter than on some other stocks. The fruit produced by trees on rough-lemon stock, while often good in dessert quality, is frequently inferior to that grown on sour orange, and it can not be held on the tree so late in the season. Tangerine trees grown on it will usually not hold their fruit after the middle of January. The Parson variety of orange is seldom successfully grown on rough-lemon stock.

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[9] Swingle, W. T., and Robinson, T. R. Two important new types of citrus hybrids for the home garden, citrangequats and limequats. Jour. Agric. Research, v. 23, no. 4, Jan., 1923.

Grapefruit seedlings have been used as stocks to a limited extent in southern Florida. They are too tender for the colder sections of the State. This stock is more vigorous in growth than the sour orange but less vigorous than the rough lemon. It is best adapted to moist soils, well supplied with humus. As grapefruit seedling stocks are less hardy and less resistant to disease than sour-orange stocks, the latter are generally more satisfactory.

The trifoliate orange, formerly known as *Citrus trifoliata*, is the hardiest stock for citrus fruits in common use. It is deciduous and has a distinct dormant season in the winter. This dormancy has the effect of checking the winter wood growth of varieties budded on it, causing them to be less susceptible to low temperatures. For this reason trifoliate-orange seedlings are much used as stocks in the colder sections of the Gulf States. They are rarely desirable as stocks in southern and central Florida and have given unsatisfactory results in the Rio Grande Valley section of Texas, where the sour orange is the preferred stock for all varieties.

The trifoliate-orange stock is best adapted to rich moist soils and is unsuited to light dry soils. It is particularly well adapted to sandy loam soils with a clay subsoil. On the proper soils it produces thin-skinned fruit of high dessert quality. It has a tendency to dwarf the growth of the tree budded on it. In the lower Mississippi Delta, Washington Navel oranges are frequently budded on trifoliate-orange stock, and while the growth is less vigorous in that locality they are more prolific than when budded on sour-orange stocks. Two other stocks occasionally used and apparently possessing much merit in some sections of Florida are the bitter-sweet orange and the Cleopatra mandarin. The latter has the advantage in the nursery of immunity to citrus scab and at the same time possesses the attributes of the sour orange in resistance to foot-rot and in hardiness.

Lemon and lime seedlings are occasionally used as citrus stocks, but are too tender for general planting.

SELECTION OF BUDWOOD.

The source of budwood used in propagation is an important consideration.

Investigations conducted in California by the United States Department of Agriculture have shown that there is a great degree of variation within the standard citrus varieties grown in that State. When these variations of trees or fruit are very marked they are known as strains. Each strain, while retaining the general characteristics common to the variety, has clear-cut differences, either in character of fruit, foliage, habit of tree growth, or production of fruit, so that it can be easily distinguished from other strains of the same variety. Furthermore, the trees of some strains are more prolific and bear much finer fruit than other strains of the same variety.

These investigations have also shown that trees propagated with selected buds from parent trees of these best strains perpetuate the characteristics of these desirable strains and come into bearing earlier and bear heavier and more uniform crops than trees propagated from buds which are not so carefully selected.[10]

Similar differences have been found to exist in the various varieties of citrus fruits grown in the Gulf States. In purchasing citrus trees for planting, growers should ascertain that they have at least been budded from trees which are true to the varietal name and, if possible, from trees which have a reputation for producing large quantities of fine fruit.

Growers and nurserymen interested in the methods of securing records from parent trees and in the subject of bud selection in general can secure detailed information by writing to the Office of Horticultural and Pomological Investigations, Bureau of Plant Industry, United States Department of Agriculture, or by requesting from the Division of Publications, United States Department of Agriculture, Farmers' Bulletin 794, entitled "Citrus-Fruit Improvement: How to Secure and Use Tree-Performance Records."

NURSERY METHODS.

Citrus trees for planting are usually purchased from commercial nurseries, and few growers to-day propagate their own trees. Seeds of sour-orange, rough-lemon, and other citrus fruits used as stocks are extracted from the fruits and sown in well-prepared seed beds. This sowing is usually done in December and January, except in the case of trifoliate-orange seeds, which are more commonly sown in September and October. The seeds are sown in rows about 2 feet apart, and the young seedlings are well fertilized and cultivated until they are large enough for transplanting. When the seedlings are 1 year old and 6 to 15 inches high, or when they are 2 years old and 15 to 24 inches high, they are transplanted to nursery rows. These rows are about 4 feet apart, with the trees a foot or more apart in the rows. After one or two seasons in the nursery row the seedlings will measure half an inch in diameter at the crown, and they are then ready for budding.

Budding may be done at any season when the bark slips readily. The ordinary shield-bud method is used in much the same way as with apples and pears. Waxed cloth is commonly used for wrapping the buds. In the spring the seedling tops are cut away, and the growing bud shoots are tied and staked.

When the buds have made a growth of about 30 inches they are pinched back and thus made to branch. The budded trees are ready for planting in the permanent grove when 1 year old, although they are often left in the nursery row and sold when 2 or 3 years old. When thrifty and well grown, 1-year-old buds, i. e., trees that have made one season's growth in the nursery from the bud, are quite as satisfactory as older trees and are usually less expensive.

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[10] Shamel, A. D., Scott, L. B., and Pomeroy, C. S. Citrus-fruit improvement: A study of bud variation in the Washington Navel orange. U. S. Dept. Agr. Bul. 623, 146 p., 16 fig., 19 pl. 1918.

——— ——— ——— Citrus-fruit improvement: A study of bud variation in the Valencia orange. U. S. Dept. Agr. Bul. 624, 120 p., 9 fig., 14 pl. 1918.

——— ——— ——— Citrus-fruit improvement: A study of bud variation in the Marsh grapefruit. U. S. Dept. Agr. Bul. 697, 112 p., 14 fig., 11 pl. 1918.

——— ——— ——— and Dyer, C. L. Citrus-fruit improvement: A study of bud variation in the Lisbon lemon. U. S. Dept. Agr. Bul. 815, 70 p., 14 fig., 8 pl. 1920.

GROVE MANAGEMENT.

PLANTING THE GROVE.

Clearing.—Before planting, the land should be thoroughly cleared of all native growth. Occasionally some of the larger trees are left standing in order to save the expense of clearing or as shelter trees to protect the young groves from frost and sun (fig. 5). Such trees left in the grove, however, rob the young trees of water and plant food and seriously interfere with the ease of cultivation. Except in the extreme northern citrus regions where frost protection is of vital importance, it will be found a cheaper and much more satisfactory practice in the end to remove all the native growth and thoroughly clear the land before the grove is planted. After clearing, the land should be plowed moderately deep, harrowed and leveled, and the soil put in as good tilth as possible. It is usually advisable to fence the land as a protection from livestock.

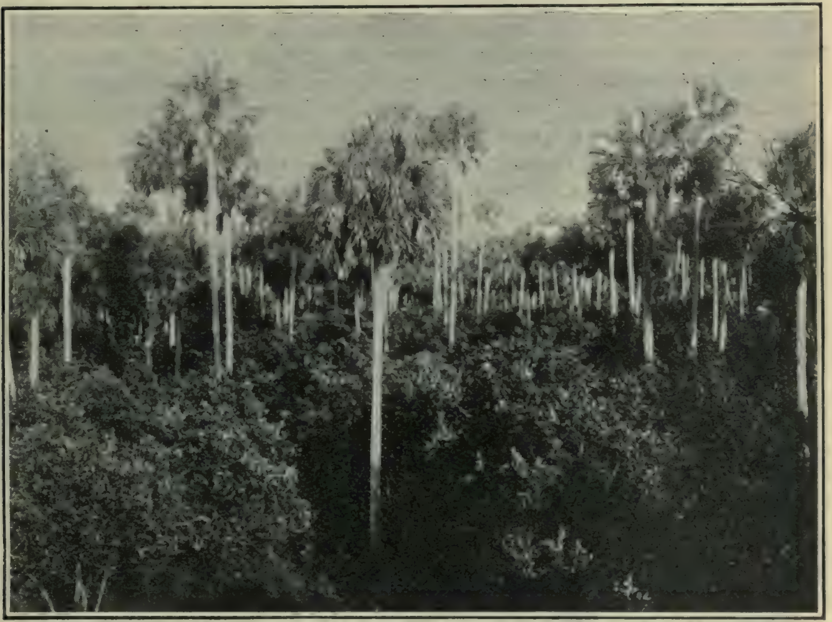

FIG. 5.—Florida orange trees planted among the native growth of palmettos.

On rich low ground an application of lime is often made after plowing, at the rate of 1,000 pounds of slaked lime to the acre. Ground limestone may be used instead, at the rate of 1 ton to the acre, applied a year or more before the trees are set. However, lime is of doubtful value to citrus trees in Florida, and it should not be used in large quantities, especially on light soils.

Many growers advise the sowing of a cover crop on new land the summer before the trees are planted. This is an excellent plan, as the cover crop shades the bare land from the sun, and when turned under in the fall it adds humus and greatly improves the condition of the soil. When the ground is in good condition, however, the trees may be planted at once and cover crops sown later between the tree rows.

Planting season.—Citrus trees may be planted at any season of the year when the wood of the trunks is firm and they can receive proper attention as to water, protection, and other care. In Florida planting is usually done either in the winter, from December 15 to February 15, or in summer after the rainy season starts. The winter is preferred, as at that season the ground is cool and moist and the trees become well established before the spring drought begins.

Most nurserymen offer their customers expert assistance in the planting and care of young trees, and where the grower is inexperienced it is often an excellent plan to secure such advice.

Planting plan and distances.—Groves are usually laid out in square or oblong rectangles, with the tree rows intersecting each other at right angles.

Opinions differ greatly as to the best distance apart for planting citrus trees. No specific distance can be given, as the proper spacing depends upon the soil, the stocks on which the trees were propagated, and the variety planted. Many citrus groves have been planted too close. It is important to plant the trees far enough apart for convenience of spraying, cultivation, and other operations and so that the trees when fully grown will not shade and crowd each other.

A common distance for setting orange and grapefruit trees in Florida is 25 by 25 feet. In rich soils 30 by 30 feet is often preferred. A few growers set oranges and grapefruit 20 by 20 feet apart, or even closer, but such close planting is rarely advisable. Grapefruit trees often have a greater spread than oranges, and it is usually desirable, even on the same land, to space them at a greater distance. Tangerines are planted at the same distances as oranges. Satsuma oranges are set a little closer, frequently 20 by 20 feet or 15 by 20 feet. Lemons are usually planted 20 by 25 feet apart, limes 15 by 20 feet, and kumquats 10 by 15 feet.

In the other Gulf States citrus trees are planted considerably closer than in Florida, especially when budded on trifoliate-orange stocks, which somewhat dwarf the trees. This close planting is also advantageous as a protection against cold and winds. In these sections orange and grapefruit trees are commonly set 20 by 20 or 20 by 15 feet apart and Satsumas 15 by 20 feet apart.

Some growers have planted their trees close together with the intention of removing every alternate tree at maturity or when the trees begin to crowd. This close planting increases the production during the first five years or so after the trees come into bearing and sometimes gives excellent results. Unless the grower has the courage, however, to cut out the alternate trees before they begin to interfere with each other, he will do best to confine his planting to the standard distance. But sometimes large bearing trees are transplanted profitably to new locations.

Wherever more than one variety of citrus fruit is planted, each sort should be in a block by itself. It is much easier to harvest the fruit and to spray effectively when the trees are set in this way than where several varieties are mixed together.

After the ground has been prepared a stake should be set where each tree is to be planted. The tree rows should be laid out with great care in order to have them exactly straight. For large plantings the services of a surveyor may be secured. The inexperienced grower will find little difficulty in obtaining competent advice on this matter of laying out the grove. (Fig. 6.)

Setting the trees.—It is best to plant the trees as soon as possible after they are received from the nursery. If planting must be delayed the trees should be removed from the boxes or bales in which they are shipped and heeled in to prevent the roots from drying out. The roots should never be permitted to become dry, even for a short time. When they are taken to the field for planting they should be kept covered with wet sacking or carried in a barrel half filled with water.

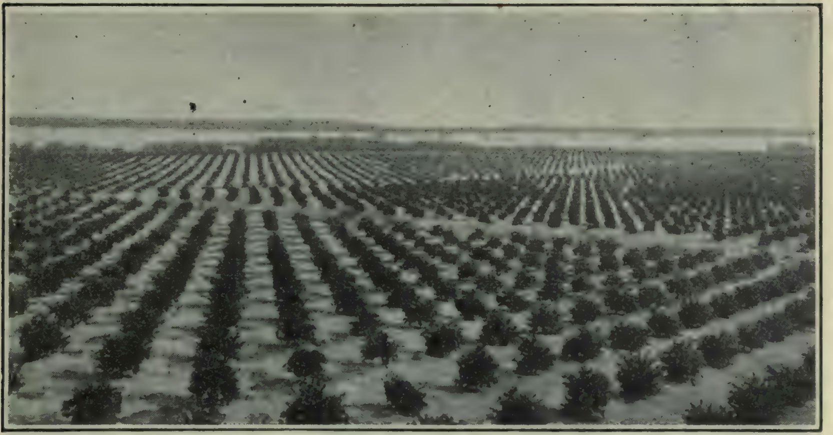

FIG. 6.—A well laid out 2-year-old citrus grove at Lucerne Park, Fla.

The holes dug for the trees should be of ample size to receive the roots without crowding and should be dug at planting time, or at most not more than a day or so before the trees are set, as otherwise the soil will dry out too much. Just before they are planted all bruised and broken roots should be trimmed from the trees with a sharp knife. The trees should be set at the same level or an inch or so higher than they stood in the nursery. If set deeper the roots fail to make the best growth. The roots should be evenly spread out in the bottom of the hole and surface soil packed among them until they are well covered. It is very essential that this soil be well firmed and packed so that it is in close contact with the roots. Many growers mix in a pound or so of good commercial fertilizer with the soil used for filling the tree holes. Stable manure should not be used in direct contact with the roots at planting time, as it is sometimes injurious to young citrus trees (fig. 7). In marl soils, however, manure well worked into the tree mounds before planting has proved decidedly beneficial. After the hole is filled with well-packed soil a shallow basin should be made about the tree (fig. 8) and 5 or 10 gallons of water applied (fig. 9). To prevent the evaporation of moisture this basin should then be covered with a mulch of grass, leaves, or dry soil. When there is danger of frost, the basin should be omitted and the trees mounded with soil so that the lower portion of the tree up to a point well above where it was budded on the stock is protected from the cold. If the top is frozen back to the mound a new top can be developed from the protected part of the trunk. Dry, clean sod, free from waste or litter, should be used, as trash frequently attracts wood lice. As soon as the danger from cold is over, the mounds should be removed, as soil left mounded about the trunk in hot weather may favor bark diseases.

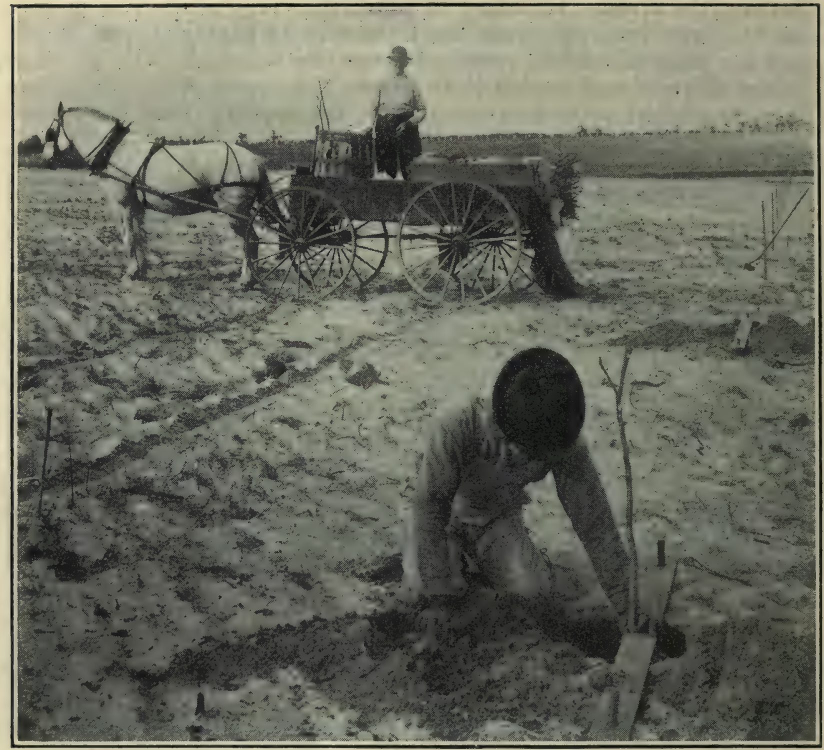

FIG. 7.—Planting a citrus tree, using a planting board. The trees are carried in a half barrel of water on the wagon until ready to go into the ground.

After the trees are planted they should be watered from time to time whenever their appearance indicates the need. Except during the rainy season the ground should be cultivated so that a dust mulch is formed and evaporation checked.

Pruning the trees at planting.—As soon as the young trees are planted, the tops should be cut back to make up for the heavy pruning which the roots have received in transplanting, as the balance between the root system and the top must always be maintained.

Trees with a single unbranched stem are headed back to a bud at a height of 2 or 3 feet from the ground. Most growers prefer the lesser distance and make low-headed trees. Three or four lateral branches, well distributed about the upper 12 inches of the tree, should be permitted to grow and all other branches removed as soon as they start. When the trees are planted with a top already formed, the undesirable branches should be pruned off and only three or four desirable limbs left. These should be cut back to spurs with two or three buds on each spur. Weak trees and trees which fail to start readily after planting should be pruned still more severely. Trees that are well headed at planting time and carefully pruned for the next few years will need very little pruning after they reach maturity.

After the grove is planted it is an excellent plan to make an accurate diagram, showing the location of each tree and variety.

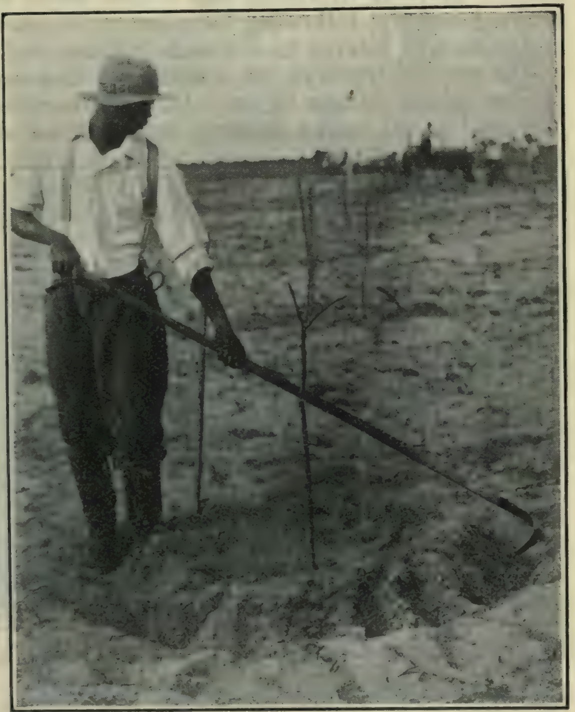

FIG. 8.—Making a shallow basin around a citrus tree after planting. This basin will be filled with water and finally covered over with a mulch of dry earth.

SYSTEMS OF MAINTAINING SOIL FERTILITY.

A system of soil management should be planned which will add humus to the soil, conserve moisture and fertility, and maintain the soil in the best condition for tree growth. The best system of cultivation will depend upon the particular conditions in each grove.

CLEAN CULTIVATION AND THE COVER-CROP SYSTEM.

Clean cultivation throughout the year, once widely practiced in Florida, has been abandoned, as it was eventually found that this method rapidly depleted the essential humus content of the soil. The most widely used system of handling soil in Florida is that of combining clean cultivation in the dry season with cover crops during the summer rainy season.

The main object of clean cultivation is to form a mulch of dry soil, so as to prevent the evaporation of moisture from below. This dust mulch is secured by plowing or disking the grove in the fall and harrowing at intervals of 10 days or 2 weeks throughout the dry season. It is only necessary to stir the upper 3 or 4 inches of the soil to get an effective dust mulch. Deeper tillage may injure too many of the feeding roots of the trees. Plowing should never be deep, especially in light soils. Many of the best growers never use a plow in their groves, depending entirely on the disk harrow, followed by the acme harrow.

When the summer rainy season begins, cultivation is discontinued and a cover crop sown or a volunteer growth of weeds and native grasses allowed to spring up. This cover crop grows during the summer and the following October or November is plowed or disked under to add humus to the soil. Occasionally cover crops are left on the ground through the winter, but this is a questionable practice because of the danger of fire. In case the cover crop is rank or green it should be cut with a mowing machine and allowed to wilt before it is turned under. The cover crop should not be removed from the grove, but should be worked into the soil to improve its physical condition.

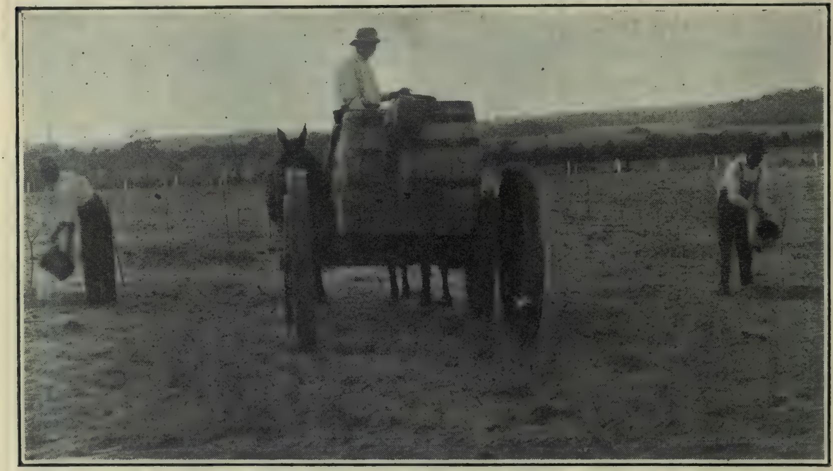

FIG. 9.—Watering citrus trees immediately after planting.

Some growers rely entirely on weeds for the cover crop, but most prefer to sow velvet beans, beggarweed, or cowpeas. All of these are leguminous crops, and in addition to adding humus to the soil they also add considerable nitrogen, which they derive from the air.

Velvet beans should be planted before the last of April for the best results. They may be sown broadcast, but it is preferable to plant them in drills or hills and cultivate the ground until they start. The bush velvet bean should be planted, as the ordinary vining varieties require some effort to keep them from running over the trees.

Beggarweed is an excellent cover crop, especially in Florida. If not cut too early in the fall it is self-seeding and will come up every year. Sometimes two or more cuttings can be made the same season. Each cutting should be left to enrich the soil.

Cowpeas are a favorite cover crop in the Gulf States except in Florida, where they are only occasionally used. The Iron and Brabham varieties are the best to plant, as they are resistant to nematodes. In some sections the fine-leaved varieties of the soy bean, such as the Laredo and Otootan, are proving valuable as green-manure and cover crops.

One objection to these leguminous cover crops is that they attract pumpkin bugs, sometimes a serious pest on citrus trees. When pumpkin bugs are numerous the cover crop should be cut by September 15. The cover-crop growth close to the trees and between the trees in the tree rows should be cut first, using a scythe where necessary. The pumpkin bugs, few of which are able to fly or travel far at this season, will then be forced to concentrate in the cover crop still standing in the row middles. When this part of the cover crop is cut the bugs are destroyed before they reach the dangerous stage.[11]

In southern Alabama and Mississippi some modifications of the cover-crop system followed in Florida groves have been found necessary. These modifications apply to the Satsuma orange on the trifoliate-orange stock, a highly specialized form of citrus industry.

Experience in this section has proved that in young groves (up to 6 or 8 years old) it is not wise to cease cultivation with the beginning of summer and allow a cover crop, volunteer or planted, to grow throughout the summer months. Cultivation is continued well into July, when a cover crop, such as cowpeas, is planted, preferably in rows, so that one or two cultivations can be given. This cover crop is turned under in the fall and the grove put in good tilth for the winter.

Where the soil is subject to washing a winter cover of rye or oats should be used. This system with adequate applications of well-balanced fertilizers results in the trees going into the winter in a vigorous condition, enabling them to stand low temperatures much better than trees weakened by inadequate cultivation and fertilization.

MULCHING SYSTEM.

A mulching system is used successfully by some citrus growers. Until about the tenth year clean cultivation in combination with cover crops is practiced, and after that time the weeds and grasses are allowed to grow the year round. The weeds are mown once or twice a year and left on the ground as a mulch. Leaves, hay, and other materials are sometimes brought into the grove and added to this natural mulch. Very fine fruit is produced by this mulching system, especially on moist hammock soils, but in nearly all groves the combination of clean cultivation with the cover-crop system will give better results.

FLAT-HOEING SYSTEM.

In a few groves all of the tillage is done with hoes. The weeds and grasses are cut off frequently at the surface of the ground and left as a mulch. This system, known as "flat hoeing," is most widely practiced on the rocky limestone soils of Dade County, Fla., where ordinary cultivation with harrows is impracticable.

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[11] Watson, J. R. Insects of a citrus grove. Fla. Agr. Exp. Sta. Bul. 148, pp. 165–267, figs. 75–142. 1918.

INTERCROPS IN THE GROVE.

Profitable interplanted crops may sometimes be grown in the groves while the trees are young and before they require all the space. The land next to the young citrus trees should be kept cultivated and only the row middles used for the production of these intercrops. Work animals used in such plantings should at all times be equipped with muzzles to prevent their grazing on the trees, frequently a cause of much injury.

On fertile soils truck crops, such as lettuce, beans, or cabbage, may be grown. In Florida, Natal hay and other forage crops are sometimes grown between citrus trees, but this practice is not to be recommended. Peaches are occasionally planted as intercrops and bear three or four crops before they are cut out. None of these intercrops should be planted close to the young citrus trees or allowed to impoverish the soil. Care must be taken, especially in growing vegetable intercrops, that the heavy fertilization does not overstimulate the citrus trees.

FERTILIZERS.

Most of the citrus soils in the Gulf States require the addition of fertilizers for the production of the most profitable fruit crops. The kind, quantity, and frequency of application of such fertilizers are all much-debated questions. They vary so greatly in each grove that only the general principles of citrus fertilization can be set forth in this bulletin.

The newcomer in a citrus section should consult growers of long experience in his locality and be guided by their advice in fertilizing his grove. He should also experiment for himself in the use of the various fertilizers, so as to determine the best combination and quantities for his conditions, which may differ from those even in adjacent groves. No cultural problem is more important or demands closer study on the part of the grower than that of fertilization.

The necessary elements of plant food which must be added to the soil in fertilizers are nitrogen, phosphorus, and potash. Nitrogen plays an important rôle in the production of new wood and leaf growth. Deficiency of nitrogen is indicated by yellow foliage and stunted growth of the tree. Excess of nitrogen, on the other hand, results in what is termed die-back, which causes the fruit to become thick skinned and puffy. The principal sources of inorganic or mineral nitrogen are nitrate of soda and sulphate of ammonia. The former is very quick in its action, while with sulphate of ammonia the effects are much slower. The chief sources of organic nitrogen are cottonseed meal, tankage, dried blood, and other plant or animal material. These are slower in their action than most inorganic nitrogenous fertilizers, and they must be used with care to avoid die-back. Nitrogen is also supplied to the soil in considerable amounts by velvet beans, cowpeas, and other leguminous cover crops.

Phosphorus is considered necessary for the proper development of the fruit. The chief sources of this element are bone and acid phosphate.

Basic slag, also known as Thomas phosphate, and ground raw phosphate rock are sometimes used as sources of phosphorus with good results on very heavy acid soils rich in humus. On nearly all Florida citrus soils, however, their action is too slow to make them either cheap or desirable fertilizers.

The common sources of the element potassium are sulphate and muriate of potash. The sulphate form is preferable, since the muriate sometimes has an injurious effect on citrus trees.

During the war with Germany potash became very scarce, and growers who formerly used 10 per cent or even more of this element in their fertilizer mixtures were unable to secure such a large percentage. A reduced quantity of potash has now been used for several seasons, but without apparent detriment to the trees or the fruit. As a result of their experience most citrus growers are continuing the application of this reduced amount of potash, using from 5 to 8 per cent of this element instead of the much greater proportion formerly applied.

FERTILIZERS FOR YOUNG TREES.

In Florida the usual practice is to fertilize young citrus trees three or even four times annually. The first application is made in the spring at the time the first flush of growth starts. One or two applications are made in summer and the last early in September. The spring and summer applications contain about 5 per cent of nitrogen, 6 to 8 per cent of phosphorus, and 2 or 3 per cent of potash. For the last application in the early fall the nitrogen is reduced to 2 or 3 per cent, in order to permit the trees to harden up in good shape for winter.

The total fertilizer used on trees the first year they are set is from 1 to 2 pounds. This is increased about a pound a year until the trees are 5 or 6 years old and begin to bear commercial crops of fruit.

FERTILIZATION OF BEARING TREES.

With bearing trees relatively less nitrogen is used than with younger trees, as it is not desirable to force wood growth. Three applications a year are usually made with mature trees. The spring and summer applications contain 3 or 4 per cent of nitrogen, 7 or 8 per cent of phosphorus, and 5 to 8 per cent of potash. The last application for bearing trees in Florida is made between November 15 and December 15 and contains but 2 or 3 per cent of nitrogen, with the same amounts of the other elements used in the spring and fall applications.

Bearing orange trees when 10 years old receive from 15 to 30 pounds of fertilizer a year. This quantity is increased as the crops become larger. Large bearing trees receive from 30 to 75 or more pounds of fertilizer annually. Many growers fertilize grapefruit somewhat more heavily than oranges.

The quantities of fertilizer used will vary with the type and fertility of the soil. Those specified above are applicable to soils of medium fertility, such as the best class of Florida high pineland. On lighter, sandier soils the amount of fertilizer is increased 25 per cent or more, while on rich hammock soils it is reduced 25 per cent or even more. On rich soils it is also often advisable to reduce the relative proportion of nitrogen used in the formula. Where nitrogen-collecting leguminous cover crops are grown the amount of commercial nitrogen applied may also be somewhat reduced.

Trees that have been overfertilized may become affected with die-back. Die-back is nearly always combined with excessive growth and overfeeding, in contrast to mottle-leaf, or frenching, which affects weak, insufficiently nourished trees. The fruit on trees affected with die-back is coarse and puffy, or is "ammoniated," as the grower would say, and the young growth is often sickly and abnormal. Where such a condition exists, the amount of fertilizer should be reduced and cultivation stopped until the trees recover their normal condition.

Sometimes die-back is due to hardpan, poor drainage, or other unfavorable soil conditions, which must be remedied before the trees can permanently recover.

Copper sulphate (bluestone) has been found an effective aid in correcting some forms of die-back. It should be used in finely granulated form, well distributed over the root-feeding area, not closer than 1 foot from the trunk of the tree. The dose should vary from a few ounces for young trees to a maximum of 3 pounds for large trees.

METHODS OF APPLYING FERTILIZERS.

Fertilizers should be spread evenly over the ground and then cultivated into the soil. Some growers broadcast their fertilizer by hand, but a fertilizer distributor is preferable, especially when the grove is large. The fertilizer should be distributed well out over all the ground shaded by the branches, so that the entire widespreading root system may be reached. In mature groves practically all the ground should receive fertilizer, while with very young trees it is only necessary to spread the fertilizer over a strip 3 or 4 feet wide on either side of the trunk. Care must be used to see that the fertilizer is kept a foot or two away from the trunks, as it is sometimes injurious to the crown roots.

BARNYARD MANURE.

In Florida the opinion prevails that barnyard manure is injurious to citrus trees and that its use frequently results in die-back. It is true that stable manure may have a bad effect, especially on trees growing in light soil, when it is applied in large quantities. When applied in small quantities, however, it is often one of the best fertilizers for citrus trees. Besides adding humus, stable manure promotes beneficial bacterial action in the soil.

Stable manure may be used profitably in somewhat heavier applications on heavy soils than on light, thin soils. On the comparatively heavy soils of California, as well as in Alabama and Louisiana, it is used in large quantities in the citrus groves with excellent results. On the lighter Florida soils the organic nitrogen of stable manure becomes available much more quickly than on heavier soils. For this reason stable manure must be used in smaller quantities on light soils in order to prevent overstimulation of the trees.

Lime is sometimes beneficial, especially on heavy soils rich in humus, but it must be used with caution, as heavy applications release plant food too rapidly, with the result that the soil becomes burned out and the tree growth impaired. On light citrus soils the use of lime is rarely advisable.

There are indications that citrus trees affected with the so-called mottle-leaf may be benefited greatly by a judicious use of stable manure. Mottle-leaf, or frenching, is of very common occurrence in Florida citrus groves. The affected trees have a general sickly, backward appearance, and the leaves show pronounced splotches of yellow between the veins and the midribs. In many cases the trouble seems to have originated through a too rapid depletion of soil humus, following applications of lime or intensive cultivation. Consequently, lime must be used with care on light soils. In the investigations mentioned above, it has been shown that mottle-leaf may be overcome and the trees restored to normal condition by the application of light amounts of stable manure combined with the growing of cover crops so as to restore the soil humus content.

Trees which by a general sickly appearance and yellowish leaves indicate a lack of nitrogen may also be benefited by several light applications of manure.

PRUNING CITRUS TREES.

When properly headed at planting time citrus trees require little pruning later. The general methods of pruning the trees when they are first set out were described in connection with the planting directions.

The pruning given during the first few years of the tree's life should be a continuation of that started when the trees were planted. All undesirable branches should be removed while they are still small and three or four limbs developed as a framework. Long, weak limbs that do not show a tendency to branch should be headed back, so that the tree will be kept strong, compact, and symmetrical. The top of the tree should not be allowed to become too dense, while on the other hand it should not be left so open that the trunk and inside branches are exposed to sun scald. Whenever it is necessary to prune off limbs whose removal will leave the inner branches exposed to the sun, the exposed branches should be protected from sun injury by a liberal coat of whitewash applied to reflect the heat. Bearing trees well cared for will need but little pruning. This pruning may be done at any time of the year when most convenient. Most growers prune in summer when other work is slack. The most important object is the removal of all dead, decayed, and injured wood. Such wood when left provides a breeding place for the fungus which causes melanose and stem-end rot, and the removal of this wood will tend to reduce the chances of these diseases developing. Figure 10 shows a convenient method for economically removing brush and prunings from the grove.

It is best to maintain trees in good shape by doing what pruning is necessary every year, as heavy pruning is objectionable. However, it is often advisable to prune severely trees long neglected in order to put them into shape for good production. After a heavy pruning of this sort a vigorous growth of suckers, or water sprouts, will appear. These should be thinned out, leaving only such as may be desired for developing into permanent branches. Sometimes a few water sprouts are left along the trunk and inner limbs and pinched back to form short inner fruiting branches. With most trees, however, the shade is too dense to favor much fruiting of these inner branches.

The principal tools used in pruning are the hand shears, knife, and saw. All tools should be kept as sharp as possible. It is very important to make the cuts clean and close to the trunk or branch left. Stubs should never be left, as they do not heal over well and eventually cause weak places in the tree. The large cut surfaces may be coated over with liquid grafting wax or white-lead paint.

Frozen trees should be pruned well back to good sound wood as soon as the extent of the injury is apparent, which will usually be within a few weeks after the freeze. Benefit is secured not only through stimulation to new growth, but from the protection afforded against melanose and other diseases.

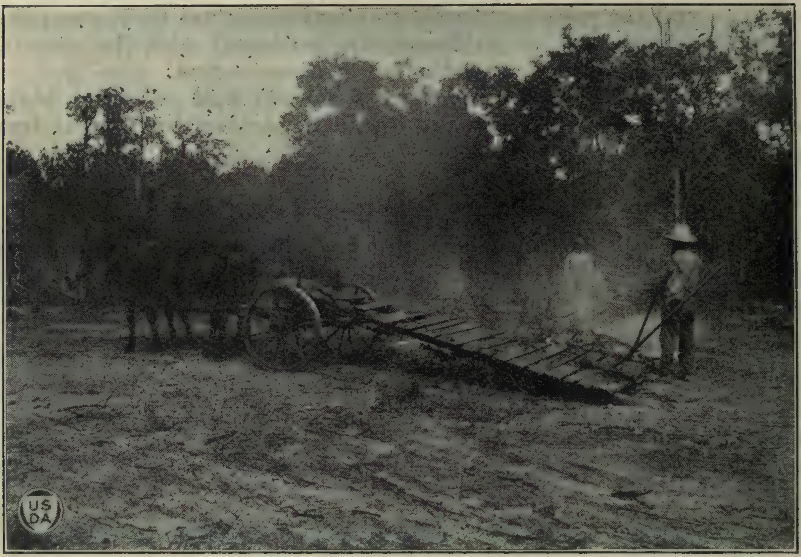

FIG. 10.—Removal of prunings from a grove for burning, Islesworth, Fla. This labor-saving contrivance materially reduces the cost of removal.

IRRIGATION.

In many of the Gulf coast sections a dry spell is frequently experienced during the spring months. These droughts are often the cause of damage to citrus trees, and some growers have resorted to irrigation as a means of insuring the setting of a good crop of fruit. (Fig. 11.)

In planning the installation of a system of irrigation the fact must be taken into account that in some years no long droughts occur and irrigation is unnecessary. The total expense of installing and maintaining an irrigation plant must be balanced against the advantages gained during the years when it is actually needed. It is therefore best to use as simple and inexpensive a system as will do the work. In many locations in Florida an efficient irrigation system for citrus groves can be cheaply installed, and most growers who have such systems consider them profitable investments.

Information concerning the irrigation of citrus groves in Florida can be obtained by writing to the United States Department of Agriculture for Department Bulletin 462, entitled "Irrigation in Florida."

PROTECTING GROVES FROM FROST.[12]

The freezes of 1895, 1899, 1917, and other years demonstrated to the citrus grower in the Gulf States the importance of being prepared to protect his trees from frost damage.

Young trees should always be mounded in localities where killing frosts occur. In the freeze of February, 1917, thousands of young unmounded trees were frozen to the ground. In the case of properly mounded trees in the same localities new shoots sprang from above the buds and the trees were restored with very little loss of time. An exception should be noted in the case of the Satsuma on trifoliate-orange stock. Mounding Satsuma trees is a practice of doubtful value. In the freeze of 1917 in Alabama more injury was done to trees that were mounded than where no such protection was afforded, the freezing of the wet soil in contact with the bark causing severe damage in many cases.

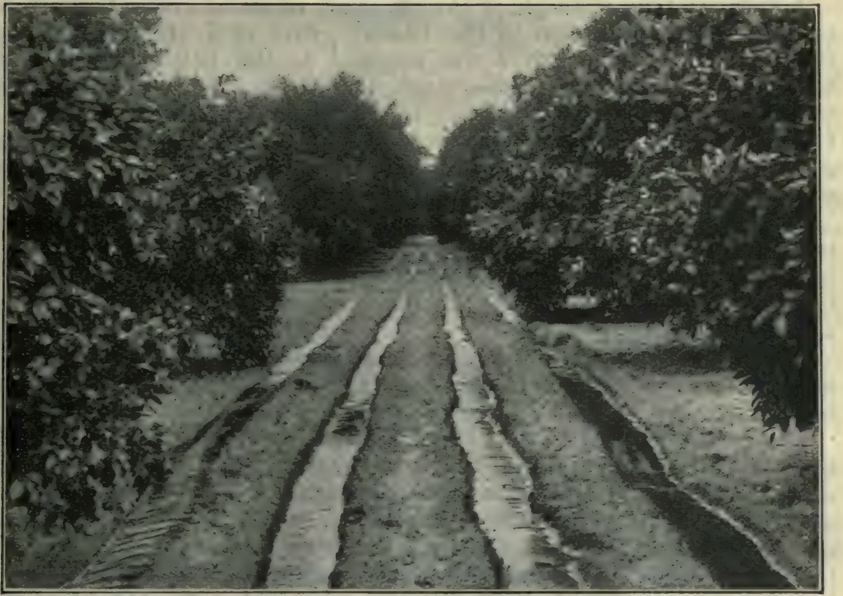

FIG. 11.—Furrow irrigation in a citrus grove, Orlando, Fla.

Many methods of frost protection have been advocated for citrus groves. Individual tents and sheds for entire groves have been tried, but were found too expensive and cumbersome. The principal methods of protection now used in the Gulf States are wood fires and coke or oil heaters. With each of these methods it has been found that it is the heat supplied and not the smoke or smudge that gives the protection.

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[12] The reader should consult Farmers' Bulletin 1096, Frost and the Prevention of Damage by It, which may be obtained free upon application to the Division of Publications, Department of Agriculture, Washington, D. C.

In the course of a survey made of the Gulf States citrus sections immediately after the freeze of 1917 the results obtained by all of these methods were studied and compared. It was found that in practically every case where wood fires were used with care and intelligence very satisfactory results were obtained, even under the most trying circumstances.

WOOD FIRES.

A very striking example of the efficiency of wood fires when properly handled was shown in the 10-acre grove of L. D. Jones, near Orlando, Fla. This grove was exposed to the full sweep of the wind and a minimum temperature of 22° F. Half of the grove was heated by a large wood fire in every alternate square of trees. In this area practically no damage was done. Trees, fruit, and even some blossoms remained uninjured. In striking contrast to this part of the grove, the unprotected half was severely damaged.

The objection is sometimes made that wood firing is not suitable in a large grove on account of the labor involved. Several very large groves, however, were efficiently and cheaply fired with wood. One grove of more than 300 acres was successfully carried through a temperature of 21° F.

For wood fuel, pine logs and pine and oak stumps are frequently used. Some growers used discarded railroad ties, which they obtain for the expense of hauling.

Growers who fired two or three nights during the freeze of 1917 used from 10 to 15 cords of wood to the acre, at a cost of about $2 a cord. The quantity used was in proportion to the exposure of the grove and the temperature experienced. In old thickly planted groves less fuel was used than in young and open plantings. The total labor cost, including the cost of hauling in wood and preparing the fires, averaged about $10 an acre, making the total cost of fuel and labor for two or three nights of firing about $40 an acre.

The most commonly used material for lighting wood fires was chips or waste from turpentine stills. A few growers used kerosene torch lighters with much success.

Most growers stow their wood in piles just outside the grove until the beginning of the danger season, when it is carried into the grove and piled in position for use. One pile in every square of four trees is usually made, particular attention being given to the north and west side of the grove. In many cases it is not necessary to light more than each alternate pile until the cold becomes intense.

For lighting and caring for wood fires in small groves one man will be needed for every 2 acres, while in larger groves with better organization and equipment one man should care for 3 acres or even more.

OIL HEATERS.

Oil heaters were used in a number of groves, but failed to give satisfaction in many cases. This was due in part to the inexperience of the growers in handling oil. The most satisfactory type of heaters were those of large capacity, holding 9 gallons or more of oil. Too much refilling was necessary where small oil reservoirs were used.

In a number of instances growers attempted to use heavy oils which had been stored for a number of years and which had become so thick that they could not be lighted. Light distillates, on the other hand, were found to be in excellent condition, even after long storage.

The chief advantage of oil heaters as compared with wood fires is that the former, when skillfully handled, often give better regulation of temperature, and the fires can be started more quickly and with less labor. On the other hand, the initial cost is very high, often exceeding $200 an acre. It is believed that for the Gulf States wood will give much more satisfaction as to cheapness and efficiency than oil.

COKE HEATERS.

Coke heaters have been used by several growers with success. The coke is burned in metal stoves of special construction.

SPRAYING CITRUS TREES.[13]

Citrus trees in the Gulf States are affected by a number of insect and disease pests. Most of these can be controlled or eliminated by proper grove sanitation, pruning, and spraying. Spraying is now recognized by most successful growers as essential to the profitable production of high-class bright fruit, as well as for the growing of healthy, vigorous trees.

The spray schedules shown in Table 3 for grapefruit and orange trees are believed to represent the minimum number of applications that will prove effective in average years for the commercial control of fungous and insect pests.

Further information concerning the nature and control of citrus diseases and insect pests in Florida and the other Gulf States may be obtained by writing to the United States Department of Agriculture, Washington, D. C., or to the appropriate State agricultural experiment station.

REJUVENATION OF OLD GROVES.

Many of the older citrus groves in the Gulf States are no longer bearing as profitable crops as they did in former years. In many groves this deterioration, usually due to neglect, is very noticeable.

Where old trees are in very bad condition, especially when they are affected with foot-rot, it is usually best to grub them out and make a fresh start with young trees of standard budded varieties. If the trunks are in sound condition, however, a thorough pruning, followed by cultivation, fertilization, spraying, and general good orchard management, will often bring run-down trees into profitable bearing in two or three seasons, provided there is no inherent fault in the soil or the locality.

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[13] The information in this section was contributed by H. R. Fulton and J. R. Winston of the Office of Fruit-Disease Investigations, Bureau of Plant Industry, and W. W. Yothers of the Office of Tropical and Subtropical Fruit-Insect Investigations, Bureau of Entomology.

TABLE 3.—*Spray schedules for grapefruit and orange trees.*

GRAPEFRUIT.[1]

Application.	Time of application.	Material.	Enemies.	Remarks.
A	About Mar. 15 to Mar. 25.[2]	3-3-50 Bordeaux mixture plus one-half of 1 per cent oil as emulsion.	Scab, early melanose, scale crawlers, and white fly.	Only partially effective against severe scab outbreaks.[3] This is a good time to spray if grower can make but one application for scab control.
	or			
A	About Mar. 15 to Mar. 25.[2]	Lime-sulphur solution, 2½ to 3 gallons to 100 gallons.	Scab, red spiders, rust mites, and scale crawlers.	Has but little effect against scab but is desirable for its effect against insect pests.
B	Apr. 5 to Apr. 15	Lime-sulphur solution 1½ to 2 gallons to 100 gallons.	Rust mites, sharkskin, tear-stain, and scale crawlers.	Probably not necessary if lime-sulphur is used in application A.
C	Apr. 25 to May 5[4]	3-3-50 Bordeaux mixture plus 1 per cent oil as emulsion.	Melanose, white fly, and scale insects.	Usually quite effective against melanose.[5]
D	June 25 to July 5	1 per cent oil as emulsion plus dry soda-sulphur, 2½ pounds to 100 gallons.	Rust mites and scales.	Very important if copper sprays have been applied during the season.
E	Sept. 1 to Feb. 1	1 per cent oil as emulsion plus dry soda-sulphur, 2½ pounds to 100 gallons.	Scale insects, white fly, sooty mold, and rust mites.	Not always necessary.[6]

ORANGE.[1]

A	Apr. 20 to May 5	3-3-50 Bordeaux mixture plus 1 per cent oil as emulsion.	Melanose, white fly, and scale insects.	Usually quite effective against melanose.[5] Probably not necessary on rather young trees where these enemies do not occur.
B	June 1 to June 15	Lime-sulphur solution 1½ to 2 gallons to 100 gallons.	Rust mites, tear-stain, sharkskin, and scale crawlers.	The critical rust-mite application.
C	June 25 to July 5	Oil 1 per cent as emulsion.	Scale insects	Very important if application A was applied.
D	Sept. 1 to Feb. 1	Oil 1 per cent as emulsion plus dry soda-sulphur, 2½ pounds to 100 gallons.	Scale insects, white fly, sooty mold, and rust mites.	Not always necessary.[6]

[1] This spray schedule should be expected to give reasonably satisfactory results under the conditions in Florida in years when the diseases and insect pests do not occur in unusual abundance.

[2] In the last of the bloom, when about three-fourths of the petals have fallen.

[3] For more complete information on scab control where the disease occurs in quantity, see U. S. Dept. Agr. Bul. No. 1118, Citrus scab: Its cause and control, or Department Circular No. 215, Commercial control of citrus scab.

[4] At least 10 days should elapse between the lime-sulphur and Bordeaux-oil applications to avoid danger of injury.

[5] For more information on melanose control, see U. S. Dept. Agr. Circ. No. 259, Commercial control of citrus melanose.

[6] For detailed information on the control of Florida citrus insects, see Farmers' Bul. No. 933, Spraying for the control of insects and mites attacking citrus trees in Florida.

In the case of groves which become crowded with age or from too close planting, it is often of advantage to remove alternate rows. The trees taken out, if healthy, can be profitably reset in new ground.

Figure 12 shows a large tree a few months after transplanting. In two to three years such trees should be bearing profitable crops. The work is best done in the winter when the trees are dormant. It is important that a large basin be made around the newly set tree capable of holding a half barrel or more of water, and water should be supplied in abundance. The main roots should be cleanly cut 2 or 3 feet from the tree trunk and handled without bruising. Soil should be very carefully packed around the roots in resetting. The tree trunks and main limbs should be whitewashed in most cases as a protection against sun scald.

There are also many old groves, consisting of seedling or inferior budded trees, which might be very profitably budded or grafted over to standard varieties. Where the work is done carefully, such undesirable sorts can often be worked over within a few years into bearing trees of Pineapple, Homosassa, and other standard varieties, worth far more than the original trees.

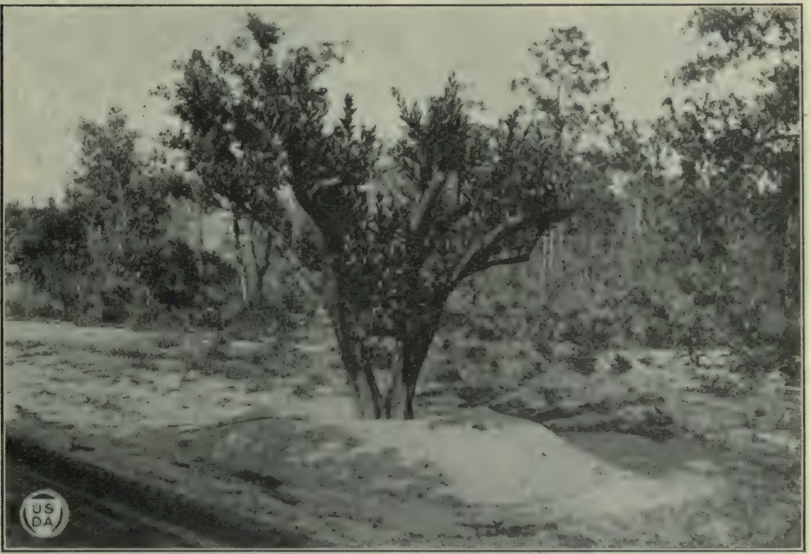

FIG. 12.—Tangerine tree, 20 years old, at Islesworth, Fla., a few months after transplanting.

In top-working undesirable trees of this sort two or three main limbs should be selected as a foundation for a new top. Additional limbs should be budded later, after the first buds have made a good start. The buds may be inserted directly into the bark of the limb itself at any season of the year when the tree is growing vigorously. Two or more buds are inserted at the base of each limb, and after these have made a good growth the old limb should be lopped off close to the new bud sprout. Grafting with the aid of paraffin by means of the Morris "slot-graft" method makes possible the insertion of grafts into old thick bark without sacrificing the top until the new graft has taken. Another method of budding large limbs is to cut them back to stubs a foot or so in length. Sprouts will soon start from these stubs, and after the sprouts are half an inch or more in diameter two or three buds may be inserted in each of them. One or two of these buds are permitted to develop at the base of each limb, and the others are eventually removed.

Mature trees may also be worked over by the methods explained in connection with the treatment of frost-injured trees.

Old orange trees on sweet-orange stocks are often badly affected with foot-rot. Such trees should be grubbed out and replaced with new trees on sour-orange or other resistant stocks. When foot-rot has not advanced too far, however, it is possible to save the affected tree by planting small resistant seedlings in the ground near the base and inarching the tops of these seedlings into the trunk of the large tree.

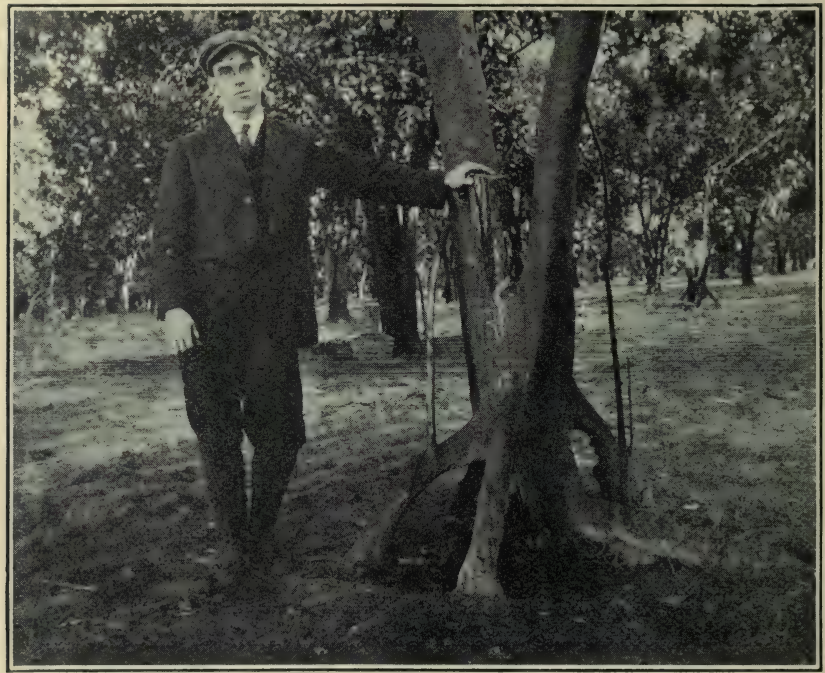

FIG. 13.—A large seedling sweet-orange tree affected by foot-rot saved by bridge grafting with resistant sour-orange stock. Dunedin, Fla.

Figure 13 shows a fine, large, seedling sweet-orange tree which has been saved by changing its root system from the original sweet stock affected with foot-rot to resistant sour-orange stock by this method of inarching.

Incipient cases of foot-rot will often yield to treatment with Bordeaux paste or lime-sulphur concentrate after thorough cleaning of the bark wounds.

TREATMENT OF FROST-INJURED CITRUS TREES.

Trees that have been injured by cold often require severe pruning. Two or three weeks after the freeze the extent of the damage will be apparent, and the trees should then be cut back to sound, healthy wood. Cuts should be made clean and close to a growing limb or sprout whenever possible. The limbs or trunks when exposed should be whitewashed or wrapped with burlap to protect them from the sun. After this pruning the injured trees should be carefully cultivated and fertilized, so that the most favorable conditions for the rapid recovery of the grove are afforded.

When the bark is badly split on the trunks and limbs as a result of frost, the loosened bark may be tacked down and tied in place with raffia or cord. When there is still some live adherent bark this treatment has given good results when performed immediately after the injury occurred, before the bark had time to dry out. Painting the trunk with grafting wax or similar material is seldom beneficial, and may result in actual injury when the area so covered is large.

Citrus trees when not banked or mounded are sometimes so badly injured by frost that it becomes necessary to cut them off at the surface of the ground below the bud. In that event the sprouts which start from the old stump may be shield budded in the same manner as seedling stocks. Some growers prefer to crown graft. This is done by first cutting the old stumps back to clean live wood an inch or so below the ground; two or more scions of the desired standard variety are then inserted between the bark and the wood, and the stump is banked with moist soil until the tops of the scions are nearly covered. If the scions fail to take, the sprouts which will start from the stump may be budded. Crown grafting is best performed when the trees are dormant in the winter or fall, while sprout budding may be done at any season of the year when the bark slips readily.

Where badly injured trees are budded or grafted by one of these methods, buds of the best-named varieties should be used. In many cases seedling trees after a freeze have been budded to standard varieties, with the result that within a few seasons the reworked trees were more valuable than before the freeze.

HARVESTING AND MARKETING CITRUS FRUITS.

The harvesting and marketing of citrus fruits is usually done by the fruit buyer or by one of the various cooperative associations rather than by the grower himself. The grower, however, should either superintend the operations in his grove and in the packing house or satisfy himself that the work is in competent hands, in order to insure that his crop may be handled in such a way that it can be marketed in the best possible condition.

Too much emphasis can not be placed on the necessity for care in the methods of handling citrus fruits at all stages. It has been shown in the course of investigations conducted in the Gulf States by the United States Department of Agriculture that much of the decay developing in citrus fruits prior to their arrival on the market is due to improper or careless methods of picking, packing, and shipping.

In clipping the fruit from the trees some style of clipper should be used that will not puncture the fruit. Picking boxes should be kept clean and free from projecting nails or splinters and gravel. The packing-house machinery should be thoroughly inspected and adjusted so that the fruit is handled with the greatest possible care. Punctures and bruises resulting from neglect of these precautions are responsible for a large proportion of the cases of fruit decay.

The loss from mechanical injuries can be in a large measure traced to the piecework system of picking and packing, i. e., payment by the box. The obvious remedy is a change to properly supervised labor paid by the day.

A recent packing-house development has been the installation of insulated rooms for the coloring of fruit, using the gas of incomplete combustion generated from oil stoves or the exhaust from gas engines for this purpose. In the case of some varieties, such as those of the Satsuma [14] type and the Parson, the development of flavor and sweetness takes place before the fruit is fully colored on the tree. In other cases, as with the Valencia when held late, fruits will often turn partially green even after once having attained full color. Such fruit is not only rendered more attractive to the consumer by coloring but a longer shipping season is made possible. The process is only legally applicable, however, to fruit that is already mature, as judged by the soluble solids-acid ratio,[15] and caution should be observed in any attempt to color fruit to make sure that only such mature fruit is used for this purpose.

Detailed information regarding the handling and shipping of citrus fruits,[16] including information on packing-house operations and precooling before transit, may be secured by addressing the United States Department of Agriculture. (Fig. 14.)

COSTS AND PROFITS IN CITRUS GROWING.

Many questions are asked as to the costs and profits in citrus growing. It is quite impossible to answer these queries satisfactorily for any particular case, for citrus culture as an investment is complicated and uncertain.

In Florida the cost of planting and caring for a citrus grove during the first four years, or until it reaches bearing age, ranges from $250 to $500 an acre. This is exclusive of the cost of the land, but it includes interest at 8 per cent on the money invested and payment for all labor done.

The price of unimproved citrus land in the Gulf States is governed by many factors, such as fertility, distance to city and shipping point, and the general standards and prosperity of the community. Desirable citrus land ranges in price all the way from $20 to $200, or even more, per acre. In some widely advertised localities the land has assumed a price too high for the conservative investor. By careful search the investor of limited means can locate desirable land at a comparatively low price, as there is plenty of low-priced land to be had in the less-developed communities.

The annual cost of maintaining a grove in Florida after it reaches bearing age averages from $75 to $150 an acre. When all or most of the labor is performed by the grove owner the cash expenditure of starting and maintaining a grove may be reduced a third or even more.

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[14] Coloring Satsuma oranges in Alabama. U. S. Dept. Agr. Bul. No. 1159.

[15] U. S. Dept. Agr., Food Inspection Decision 182.

[16] Ramsey, H. J. Handling and shipping citrus fruits in the Gulf States. U. S. Dept. Agr., Farmers' Bul. 696, 28 p., 10 fig. 1915. Available for free distribution.

Stubenrauch, A. V., Ramsey, H. J., Tenny, L. S., and others. Factors governing the successful shipment of oranges from Florida. U. S. Dept. Agr. Bul. 63, 50 p., 26 figs., 15 pl. 1914. Obtainable from the Superintendent of Documents, Government Printing Office, Washington, D. C. Price, 20 cents.

The profits in citrus growing vary even more than the costs. The returns from some of the best groves are very high indeed, while, on the other hand, there are many poorly located or poorly cared for groves that are maintained at an actual loss.

Orange and grapefruit trees in good soils and well cared for come to bearing age at about the fourth or fifth year, when they commonly yield from a fourth to a half box of fruit to the tree. The crop increases annually at the rate of about a quarter box for oranges and a half box for grapefruit until the trees come into full production about the tenth year. There are exceptional groves which yield 500 boxes per acre or even more of grapefruit or oranges in a single season, but only the very best groves average more than 200 boxes annually. The average yield for Florida, including the best as well as the poorest groves, is about 150 boxes to the acre, or somewhat less than 2 boxes to the tree. There are commercial groves in Florida producing profitable crops at an age of 30 or 40 years.

Very heavy plantings of citrus trees have been made in the last 10 years, and many growers fear the danger of overproduction. While it is true that enormous crops of fruit may be harvested in the Gulf States in the near future, it is equally true that the market demand is increasing.

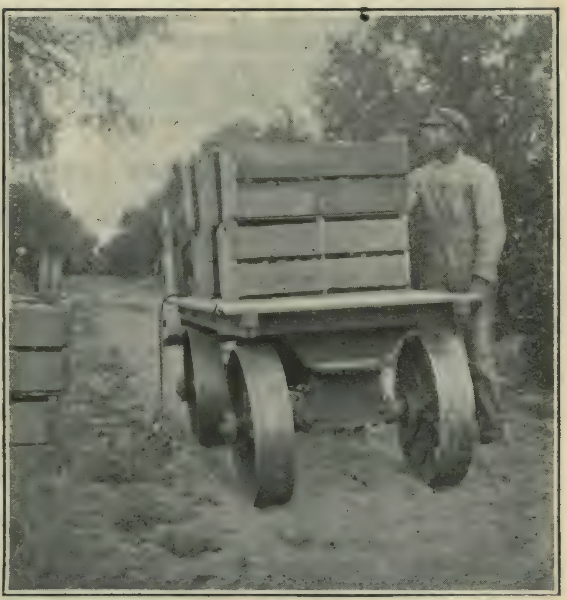

Fig. 14.—A low flat-wheeled orchard truck for hauling oranges from a Florida grove.

The increasing utilization of off-grade fruit through the newly developed canning process for grapefruit, the bottling of citrus-fruit juices, and preparation of candied fruit, will doubtless have a tendency to absorb the lower grades of fruit, thus steadying the demand for the well-grown attractive product. The development of new markets through better distribution, and the stimulation of consumption through advertising are factors of importance in maintaining a balance between production and consumption.

When all of these factors are taken into consideration it is evident that future profits in citrus culture will require the investor to exert the greatest skill and judgment at every step. Care is particularly essential when the available capital is limited. The man of wealth who invests in a citrus grove more as a winter home or a hobby than as a business has only to select a pleasing home site, of which there are very many in the Gulf States; in his case profits are of minor importance. On the other hand the man who must depend upon the returns from his grove for a living must exercise the greatest caution in selecting his grove and the greatest skill and energy in its development. The risk from frost, as well as the more common sources of loss, must be taken into consideration.

Before purchasing citrus lands or groves the investor should make a personal visit to the locality and carefully study the situation. It is rarely advisable to buy land or to develop a grove unless the owner can give the property his personal attention. It is much safer for the beginner to start in citrus growing on a small scale and expand after learning the business than to plunge heavily at the start.

The prospective purchaser can secure much valuable information by consulting successful growers, and it is an excellent plan to hire out for a season or two with some experienced grower before purchasing land or planting a grove. The United States Department of Agriculture and the State agricultural experiment stations will gladly supply information when requested.

PUBLICATIONS ON CITRUS FRUITS.

PUBLICATIONS AVAILABLE FOR FREE DISTRIBUTION BY THE DEPARTMENT OF AGRICULTURE.

Control of the Citrus Thrips in California and Arizona. (Farmers' Bulletin 674.)
Handling and Shipping Citrus Fruits in the Gulf States. (Farmers' Bulletin 696.)
Citrus-Fruit Improvement: How to Secure and Use Tree-Performance Records. (Farmers' Bulletin 794.)
Spraying for the Control of Insects and Mites Attacking Citrus Trees in Florida. (Farmers' Bulletin 933.)
Frost and the Prevention of Damage by It. (Farmers' Bulletin 1096.)
Control of the Common Mealybug on Citrus in California. (Farmers' Bulletin 1309.)
Citrus-Fruit Improvement: A Study of Bud Variation in the Washington Navel Orange. (Department Bulletin 623.)
The Composition of California Lemons. (Department Bulletin 993.)
Natural Control of the Citrus Mealybug in Florida. (Department Bulletin 1117.)
Citrus Scab: Its Cause and Control. (Department Bulletin 1118.)
Commercial Control of Citrus Scab. (Department Circular 215.)
By-Products from Citrus Fruits. (Department Circular 232.)
Commercial Control of Citrus Melanose. (Department Circular 259.)
Cooperative Improvement of Citrus Varieties. (Yearbook Separate 813.)

PUBLICATIONS FOR SALE BY THE SUPERINTENDENT OF DOCUMENTS, GOVERNMENT PRINTING OFFICE, WASHINGTON, D. C.

Culture, Fertilization, and Frost Protection of Citrus Groves in the Gulf States. (Farmers' Bulletin 542.) Price, 5 cents.
Fumigation of Citrus Trees. (Farmers' Bulletin 923.) Price, 5 cents.
Control of the Argentine Ant in Orange Groves. (Farmers' Bulletin 928.) Price, 5 cents.
Factors Governing the Successful Shipment of Oranges from Florida. (Department Bulletin 63.) Price, 20 cents.
Citrus Fruit Insects in Mediterranean Countries. (Department Bulletin 134.) Price, 15 cents.
Katydids Injurious to Oranges in California. (Department Bulletin 256.) Price, 10 cents.

The Production of Sweet-Orange Oil and a New Machine for Peeling Citrus Fruits. (Department Bulletin 399.) Price, 5 cents.

The Navel Orange of Bahia; with Notes on Some Little-Known Brazilian Fruits. (Department Bulletin 445.) Price, 20 cents.

Irrigation in Florida. (Department Bulletin 462.) Price, 15 cents.

A Humidifier for Lemon Curing Rooms. (Department Bulletin 494.) Price, 5 cents.

Citrus-Fruit Improvement: A Study of Bud Variation in the Valencia Orange. (Department Bulletin 624.) Price, 25 cents.

Some Reasons for Spraying to Control Insect and Mite Enemies of Citrus Trees in Florida. (Department Bulletin 645.) Price, 5 cents.

The Argentine Ant in Relation to Citrus Groves. (Department Bulletin 647.) Price 15 cents.

Citrus-Fruit Improvement: A Study of Bud Variation in the Marsh Grapefruit. (Department Bulletin 697.) Price, 20 cents.

Citrus-Fruit Improvement: A Study of Bud Variation in the Eureka Lemon. (Department Bulletin 813.) Price, 25 cents.

Citrus-Fruit Improvement: A Study of Bud Variation in the Lisbon Lemon. (Department Bulletin 815.) Price, 25 cents.

Frost Protection in Lemon Orchards. (Department Bulletin 821.) Price, 10 cents.

Fumigation of Citrus Plants with Hydrocyanic Acid: Conditions Influencing Injury. (Department Bulletin 907.) Price, 15 cents.

Tear-Stain of Citrus Fruits. (Department Bulletin 924.) Price, 5 cents.

The Decay of Oranges While in Transit from California. (Bureau of Plant Industry Bulletin 123.) Price, 20 cents.

A Knot of Citrus Trees Caused by Sphaeropsis tumefaciens. (Bureau of Plant Industry Bulletin 247.) Price, 15 cents.

Some Factors Affecting the Keeping Qualities of American Lemons. (Bureau of Plant Industry Circular 26.) Price, 5 cents.

The Limitation of the Satsuma Orange to Trifoliate-Orange Stock. (Bureau of Plant Industry Circular 46.) Price, 5 cents.

The Woolly White Fly: A New Enemy of the Florida Orange. (Bureau of Entomology Bulletin 64, Part VIII.) Price, 5 cents.

Fumigation for the Citrus White Fly as Adapted to Florida Conditions. (Bureau of Entomology Bulletin 76.) Price, 15 cents.

White Flies Injurious to Citrus in Florida. (Bureau of Entomology Bulletin 92.) Price, 25 cents.

Natural Control of White Flies in Florida. (Bureau of Entomology Bulletin 102.) Price, 20 cents.

Preparations for Winter Fumigation for the Citrus White Fly. (Bureau of Entomology Circular 111.) Price, 5 cents.

Spraying for White Flies in Florida. (Bureau of Entomology Circular 168.) Price, 5 cents.

Insects Injurious to Citrus Fruits and Methods for Combating Them. (Porto Rico Exp. Sta. Bulletin 10.) English and Spanish editions, each 10 cents.

Citrus Fertilization Experiments in Porto Rico. (Porto Rico Experiment Station Bulletin 18.) Price, 10 cents.

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1962

Home Tanning

# of LEATHER and SMALL FUR SKINS

Farmers' Bulletin No. 1334

U. S. DEPARTMENT OF AGRICULTURE

ORDINARILY hides and skins should be tanned only by experienced tanners. Sometimes and in some places, however, the spread between the receipts for hides and the cost of leather warrants the farmer in tanning for himself.

The inexperienced cannot hope to make leather equal in appearance, or possibly in quality, to that obtainable on the market, but farmers and ranchmen should be able to make serviceable leather for most farm purposes by carefully following the directions here given.

It is never advisable for an inexperienced person to try to tan valuable fur skins or large hides to be made into coats, robes, or rugs. The results would be disappointing, both in appearance and in quality. Small fur skins or skins of low market value, however, can be tanned for home or country use according to the directions given in this bulletin.

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Washington, D. C.

Revised February 1954
Slightly revised February 1962

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HOME TANNING OF LEATHER AND SMALL FUR SKINS

Revised by J. S. Rogers[1] and I. D. Clarke,[1] *Eastern Utilization Research and Development Division, Agricultural Research Service*[2]

THE TANNING of a few hides and skins by inexperienced persons or by those lacking proper equipment is usually inadvisable. from the standpoint both of national economy and of individual profits. Tanners are equipped to make all the leather that the country needs. They can make leather of a better quality and can do it more economically than can the farmer. Under normal conditions, then, farmers and ranchmen should try to improve the quality of the hides and skins that they produce and to market them advantageously, leaving to tanners those trade operations which call for time and equipment. Both hides and labor are often lost when tanning is undertaken by those who have had no experience in the work.

HAVING HIDES TANNED

It may be more economical to have hides and skins tanned by tanners who are willing to tan one or more hides than to do the work on the farm or ranch. Some tanners tan only hides with the hair on for robes or coats; some also tan harness, strap, lace, and glove leather; others tan only harness, strap, or lace leather; and a few tan sole leather. Some accept one-half of the hide in payment for tanning the other half. That is, if a farmer sends a hide to be tanned, the tanner will send back one-half tanned into leather and keep the other half to pay for his work. This probably is the best way for farmers to get their leather.

Depending on the size of the hide, the kind of leather, and the tanner's prices and profits, the charge for tanning a hide with the hair on or making it into leather varies from $2 to $5 for calfskins and from $5 to $15 a hide, or from 25 to 50 cents a square foot or a pound, for horse and cattle hides tanned into harness, lace, or glove leather.

Definite prices can be obtained directly only from a tanner. In writing to tanners be sure to state exactly what kind of hides you have. Give the weight of each, and ask for prices for tanning them with the hair on, making them into robes or coats, or tanning them into the kind of leather you want. The hide you have may not be suitable for the kind of leather you want. It takes a 50-pound or heavier hide to make sole or harness leather. If you tell the tanner what you have, he can tell you what it will make. A list of tanners who tan leather and furs for farmers may be obtained by writing to the Eastern Regional Research Laboratory, 600 East Mermaid Lane, Philadelphia, Pa., 19118. In supplying this list of names and addresses the Department assumes no responsibility for the reliability or quality of work of these tanners. The list simply gives the names of all who have informed the Laboratory that they will tan one or more hides for farmers.

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[1] Retired.

[2] Acknowledgement is made to R. W. Frey, retired, and F. P. Veitch, deceased, who, with I. D. Clarke, were the authors of the original edition of this bulletin.

As a rule, the tanner does not pay shipping charges either way. These, in addition to the tanning charge, must be paid by the farmer.

The regulations for shipping hides by express are now very stringent. Express companies will not accept hides for shipment unless they are packed in a keg or other container that does not leak. Consult the nearest express agent about this before shipping.

Be sure to tag each hide securely before it is shipped with your name and address and the kind of leather you wish made from it. Use a heavy manila shipping tag with metal eyelet, and write plainly with indelible pencil. If tag comes off you probably will lose the hide.

BUYING LEATHER BY THE SIDE

Many farmers state that they are offered only a few cents a pound for hides but are charged from 90 cents to $1.50 a pound for leather at retail. It may prove more economical in many cases to buy, either individually or cooperatively, leather in quantities larger than a pound or two.

In September 1961, wholesale prices for leather given in trade journals were about as follows: Heavy sole leather bends, 56–58 cents a pound; light sole leather bends, 70–76 cents a pound; sole leather bellies, 24–26 cents a pound; rough double shoulders, 50–59 cents a pound; side upper leather, 76–80 cents per square foot; calf leather, men's weight, $1.50 per square foot and down, women's weight, $1.24 per square foot and down. Leather made from packer hides usually sells for more than that made from country hides. Wholesale prices fluctuate from time to time. Definite information on prices at the time of purchase must be obtained from dealers or tanners.

By buying a single side of leather as he needs it, a farmer should be able to get it at a price not more than 10 to 20 percent above wholesale quotations. Expressage on leather brought from tanners must, of course, be paid by the purchaser. If whole sides cannot be obtained from dealers in nearby cities or towns at satisfactory prices, write the tanners for their prices.

Sole leather is principally vegetable tanned or chrome tanned and is classed as heavy, medium, and light. For quality it is graded No. 1, No. 2, and No. 3. Chrome sole leather can be bought waxed or unwaxed. Only the waxed is suitable for outdoor use. Harness leather is heavy, medium, and light, and for quality it is graded No. 1 and No. 2, or A and B.

A "side" of leather is half of a tanned hide. It weighs from 15 to 30 pounds, depending upon the size of the hide and the kind of leather. A "back" is a side of leather with the belly, legs, and head trimmed off.

Backs cost a little more than sides. A "bend" is a side of leather with the belly, legs, and shoulder trimmed off. It is the best leather of the hide and is approximately one-half the area or weight of the side. Bends cost more than either backs or sides.

A comparison of the prices at which leather can be bought with the charges for having hides tanned will show which is cheaper. As a general rule, it is believed that it is cheaper to have sides tanned one-half for the other.

HOME TANNING

Sometimes hides and skins can be sold by a farmer or rancher only at prices which are lower than the cost of production. Sometimes "country" hides can scarcely be given away, yet farmers must pay from $1 to $1.50 a pound for leather in small pieces. Under such conditions farmers naturally feel that they must either work up their raw materials or do without the finished leather. As a result, the United States Department of Agriculture has received thousands of requests for directions for farm or home tanning. To meet this demand the following directions have been prepared for tanning one or more hides or skins with only the equipment that can be had on any farm or ranch.

Although good results have been obtained in this Bureau by using the equipment and following the directions here given, inexperienced operators probably often will be unsuccessful. Every attempt, however, will add to their experience and should reduce the number of their failures. Operating on a small scale, they cannot hope to make leather equal in appearance, and possibly in quality, to that on the market. They should, however, be able to make leather which is serviceable for many purposes on farms and ranches.

The directions for tanning need not be memorized, but they must be studied carefully until thoroughly understood before the work is begun. All supplies and equipment should be on hand and all plans should be carefully made before the work is started. It may be necessary to modify the directions, especially those dealing with equipment or tanning conditions. Success in modifying them depends largely upon the individual.

Tanning operations are done best at a uniformly moderate temperature. A cellar, which is naturally fairly warm in winter and cool in summer, is a suitable place. A supply of fresh water near at hand and a drain are convenient.

All the operations can be done in tight, clean wooden barrels, preferably oak, having a capacity of from 40 to 60 gallons. When not in use the barrels should be kept clean and full of water. Half barrels and wooden or fiber buckets are useful for many purposes. Iron containers should never be used. Tools useful in tanning are shown in figure 1.

TANNING HIDES AND SKINS FOR LEATHER

The kind of leather which can be made from a hide or skin depends largely upon the weight and size of the hide or skin. In the tanning trade distinctions in hides and skins are based mainly upon the size and age of the animal and upon the class of leather. Hides from large and adult animals are suitable for sole, harness, belting, or heavy leathers. Skins from small animals, such as sheep, goats, calves, and deer, are made into light and fancy leathers. While there are other commercially important sources of hides and skins, the most important ones are the usual domesticated farm and range animals. As a general rule, the thickness of the finished leather will be about the same as that of the untanned hide. This should be a guide in selecting skins for different kinds of leather. The first essential for a satisfactory yield of good leather is a sound, clean hide or skin. Skinning should be done properly, without cutting or scoring the hide, and at the same time all of the fat and flesh should be removed; for, if left on, they increase the tendency of the hide to rot or spoil. Farmers' Bulletin 1055, Country Hides and Skins: Skinning, Curing, and Marketing, should be studied in this connection.

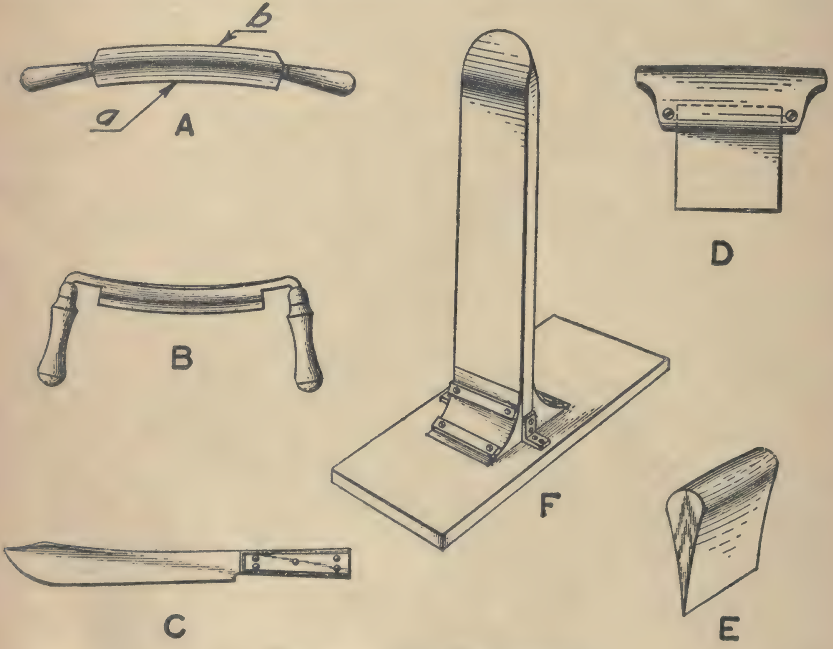

FIGURE 1.—Tools for tanning

(*A*) Tanner's fleshing knife, having a blade 15 to 17 inches long: (*a*) Dull edge for scraping off the hair after liming; (*b*) very sharp edge for shaving off the flesh.

(*B*) Eight-inch-blade drawing knife, which may be used instead of *A*, especially if both handles are bent straight. The back edge may be used for unhairing and the cutting edge for shaving off the flesh.

(*C*) Twelve-inch-blade butcher knife, which may be used instead of *A* or *B* when the point has been driven into a wooden handle or wrapped with leather.

(*D*) Metal slicker—a dull steel blade about 5 inches square, $1/32$ to $1/16$ inch thick, mounted in a wooden handle.

(*E*) Wooden slicker, made of hardwood, about 6 inches square, 1½ inches thick at head, shaved down in the shape of a wedge to a thin edge.

(*F*) Stake for breaking up and softening skins and leather. A board about 3 feet long, 6 inches wide, and 1 inch thick is braced in an upright position to a heavy base or to the floor. The top of the board is rounded and thinned in the shape of a wedge to an edge about ⅛ inch thick.

Preparation of the hide or skin for tanning may be begun as soon as it has been taken off the animal, drained, and cooled from the body heat. Overnight will be long enough. If tanning is not to be started at once or if there are more hides than can be handled at one time, the hides may be thoroughly salted, using about 1 pound of clean salt for each pound of hide. They then may be kept for from 3 to 5 months. The hides must never be allowed to freeze or heat during storage or tanning. Some tanners state that salting before tanning is helpful. It can do no harm to salt a hide for a few days before it is prepared for tanning.

The directions here given have been prepared for a single heavy cow, steer, or bull hide weighing from 40 to 70 pounds or for an equivalent weight in smaller skins, such as calf or kip skins. The heavy hides are best suited for sole, harness, or belting leather. Lighter hides weighing from 20 to 40 pounds should be used for lace leather.

PRELIMINARY OPERATIONS

Before it is tanned a hide or skin must be put through the following preliminary operations, which are the same for all the leather-making processes given in this bulletin. As soon as the hide or skin has been put through these processes, start the tanning, following the directions given for the particular kind of leather desired.

Soaking and Cleaning

If the hide has been salted, shake it vigorously to remove most of the salt. Spread it out, hair side down, and trim off the tail, head, all ragged edges, and shanks.

Place the hide, hair side up, lengthwise, over a smooth log or board, and with a sharp knife split it from neck to tail, straight down the backbone line, into two half hides, or "sides." It will be more convenient in the later handling, especially when the hide is large, to then split each side lengthwise through the "break," just above the flanks, into two strips, making the strip with the backbone edge about twice as wide as the belly strip. Thus a whole hide will give two sides or four strips. Small skins need not be split. In these directions "side" means side, strip, or skin, as the case may be.

Fill a 50-gallon barrel with clean, cool water. Place the sides, flesh side out, over short sticks and hang them in the barrel of water. The sticks must be short enough to fit crosswise in the barrel and should have a cord or small rope, a foot or so long, attached to each end. The cords or ropes are fastened to nails on the outside of the barrel after adjusting them so the sides are completely covered by water. Let the sides soak for 2 or 3 hours. Stir them about frequently to soften, loosen, and wash out the blood, dirt, manure, and salt.

After they have soaked for about 3 hours take out the sides, one at a time, and place them, hair side up, over a "beam." A ready-made beam can be bought. A fairly satisfactory one may be made from a very smooth slab, log, or thick planed board, from 1 to 2 feet wide and 6 to 8 feet long. The slab or log is inclined, with one end resting on the ground and the other extending over a box or trestle so as to be about waist high. With the side lying hair side up over the beam,

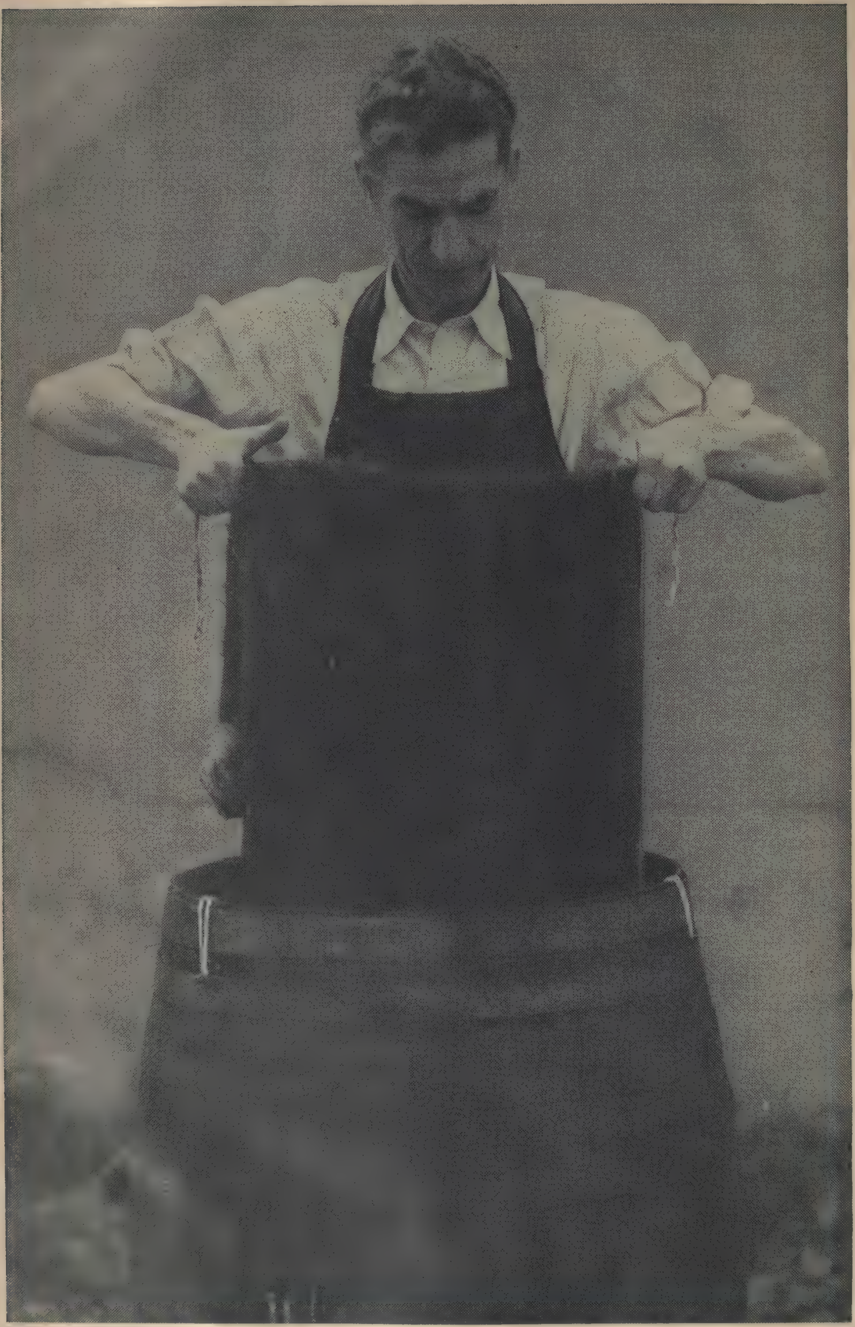

FIGURE 2.—Putting a side into limewater. The hide has been split into two sides and soaked and cleaned. Each side is folded over a stick.

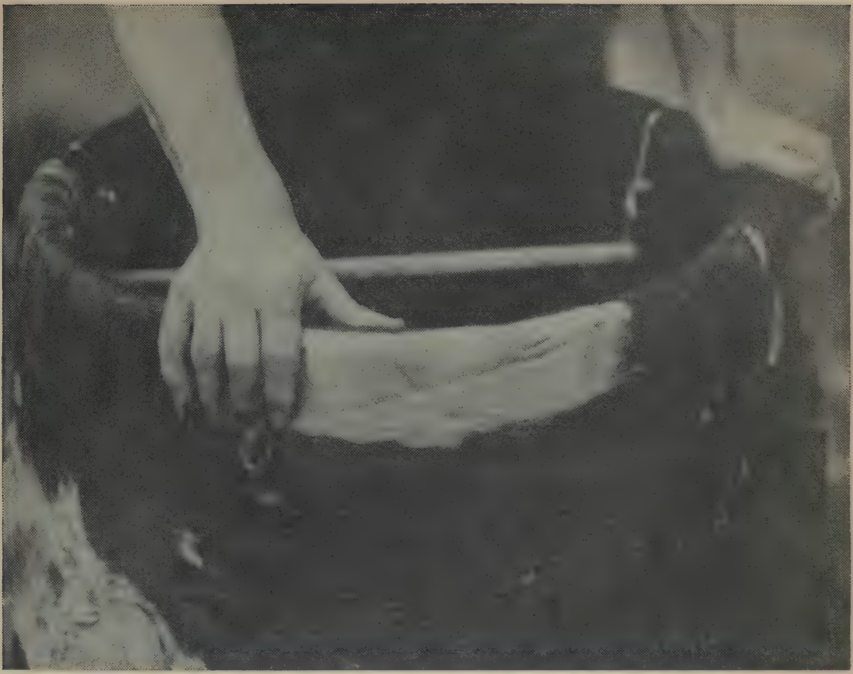

FIGURE 3.—Ready to unhair after liming. When the hair can be rubbed off easily with the hand the hide is ready to be unhaired.

scrub off all dirt and manure, using if necessary a stiff brush. Wash off with several bucketfuls of clean water.

Turn the side over, flesh side up, and scrape or cut off any remaining flesh. Work over the entire flesh side with the back edge of a drawing or butcher knife held firmly against the hide, pushing away from the body. Wash off with one or two bucketfuls of clean water. This working over should always be done.

Refill the soak barrel with clean, cool water and hang the sides in it as before. Pull them up and stir them about frequently until they are soft and flexible. Usually a green or fresh hide needs to be soaked for not more than from 12 to 24 hours and a green salted hide for not more than from 24 to 48 hours.

When the sides are properly softened—that is, when they are about like a fresh hide or skin—throw them over the beam and thoroughly scrape off all remaining flesh and fat.

The side must be soft, pliable, and clean all over before being put into the lime, which is the next step.

Liming

Wash out the soak barrel, put in from 9 to 11 pounds of hydrated lime (use lime from a fresh bag, not old, air-slaked lime) and 4 or 5 gallons of water. Stir with a paddle until the lime is thoroughly mixed with the water, then nearly fill the barrel with clean, cool water and again stir thoroughly. Again place the sides, hair side out, over the short sticks and hang them in the barrel so that they are

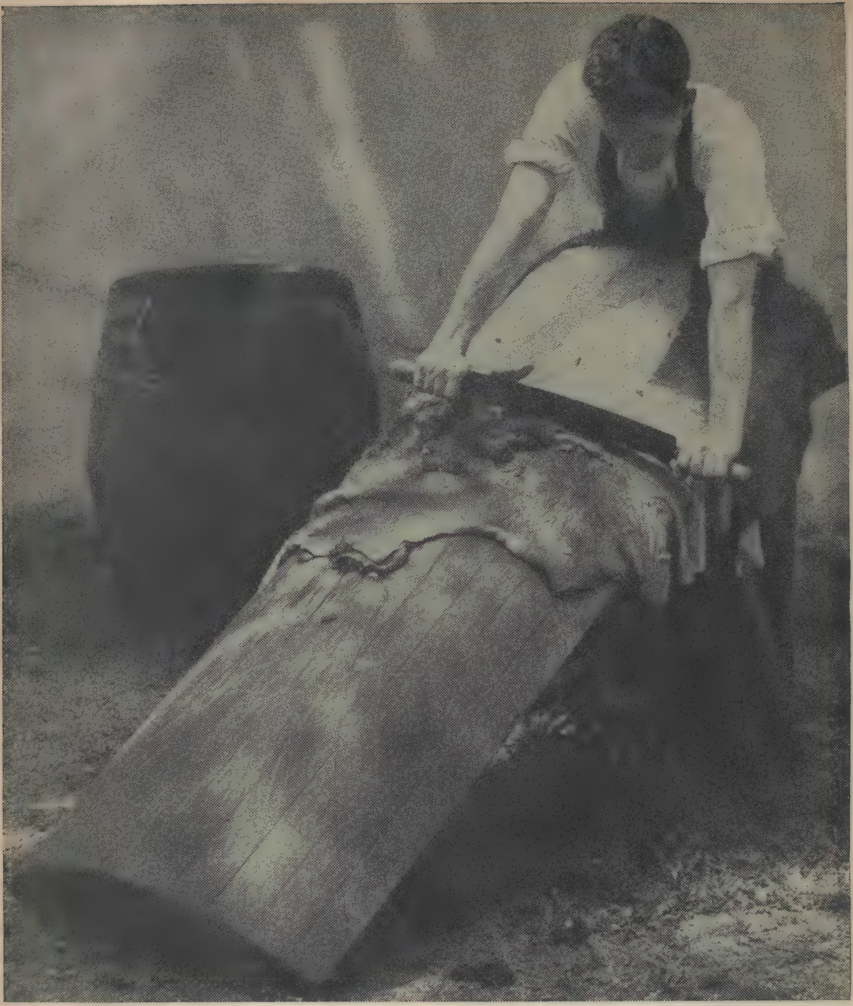

FIGURE 4.—Unhairing. After thorough liming, the hair is pushed or scraped off with a dull metal edge. At the same time some of the lime, grease, and dirt are worked out of the hide. Here the workman is using the dull edge of the fleshing knife and a tanner's beam.

completely covered by the limewater (fig. 2). See that the sides have as few folds or wrinkles as possible, and also be sure that no air is trapped under them. Keep the barrel covered with boards or bags. Pull up the sides and stir the limewater three or four times each day until the hair will come off easily. This takes from 6 to 10 days in summer and possibly as many as 16 days in winter.

When thoroughly limed, the hair can be rubbed off readily with the hand (fig. 3). Early in the liming process it will be possible to pull out the hair, but the hide must be left in the limewater until the hair comes off by rubbing over with the hand. For harness and belting leathers leave the hide in the limewater for from 3 to 5 days after this condition has been reached.

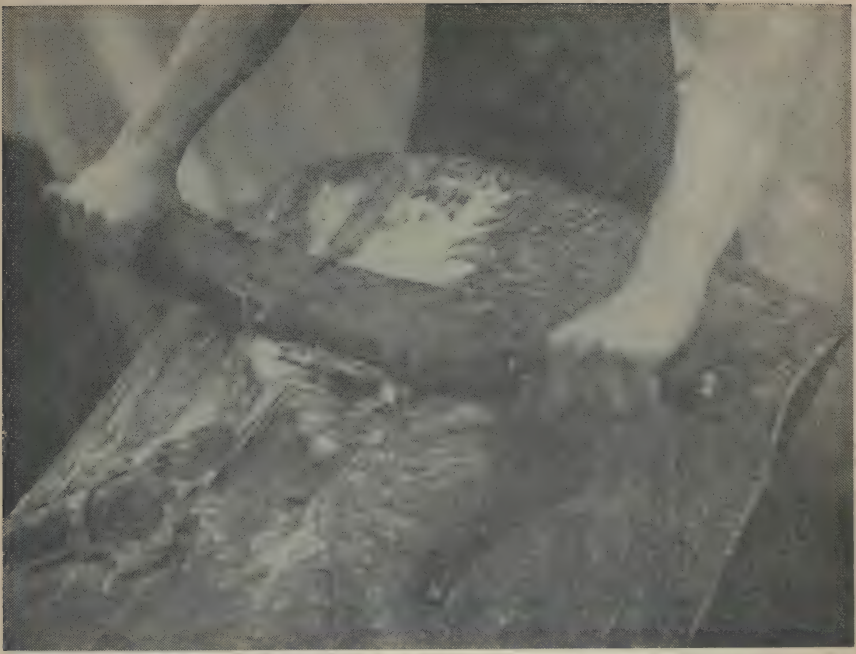

FIGURE 5.—Fleshing. All flesh, fat, and tissue must be shaved off down to the real hide or skin.

Unhairing

After the side has been limed, throw it hair side up, over the beam and with the back edge of a drawing or butcher knife held nearly flat against the side push off the hair from all parts (fig. 4). If the side is sufficiently limed, a curdy or cheesy layer of skin rubs off with the hair. If this layer does not rub off, the side must be returned to the limewater. Now thoroughly work over the grain or hair side with a dull-edged tool to "scud" or work out as much lime, grease, and dirt as possible.

Fleshing

Turn the side over and scud it again, being sure to remove all fleshy matter. Shave down to the hide itself, but be careful not to cut into it. Remove the flesh by scraping and by using a very sharp knife (fig. 1), with a motion like that of shaving the face (fig. 5).

Now proceed as directed under Bark-Tanned Sole and Harness Leather (p. 10), Chrome-Tanned Leather (p. 14), or Alum-Tanned Lace Leather (p. 19), depending upon the kind of leather desired.

Wastes From Liming

The lime, limewater, sludge, and fleshings from the liming process may be used as fertilizer, particularly for acid soils. The hair, as it is scraped from the hide, may be collected separately and after being rinsed several times may be used for plastering. If desired, it can be thoroughly washed with many changes of water until absolutely clean and after being dried out in a warm place used for padding, upholstering, insulation of pipes, etc.

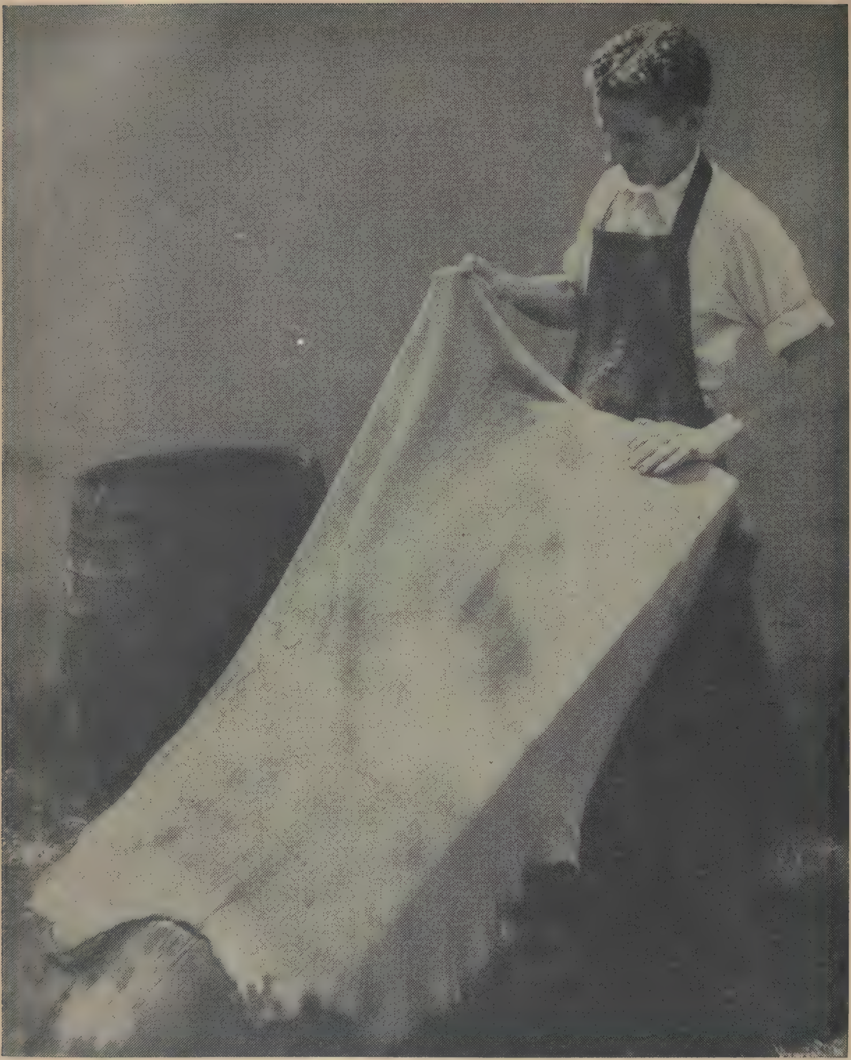

FIGURE 6.—Unhaired, fleshed hide ready to be delimed. All hair, flesh, and fat must be removed, as well as much of the lime and grease.

BARK-TANNED SOLE AND HARNESS LEATHER

Deliming

After the sides have been put through the unhairing and fleshing operations, rinse them with clean water. Wash the sides in cool, clean water for from 6 to 8 hours, changing the water frequently.

Buy 5 ounces of U. S. P. (United States Pharmacopœia) lactic acid (or 16 ounces of tannery 22 percent lactic acid). Nearly fill a clean 40- to 50-gallon barrel with clean, cool water, stir in the lactic acid, and mix the water and acid thoroughly with a paddle. Hang the sides in the barrel and leave them there for 24 hours, pulling them up and stirring them frequently.

Take out the sides, work over or scud them thoroughly, as directed under Unhairing (p. 9), and hang them in a barrel of cold water. Change the water several times, and finally leave them in the water overnight.

If lactic acid cannot be obtained, use a gallon of vinegar instead.

Tanning

The sides are now ready for the actual tanning. From 15 to 20 days before this stage will be reached, weigh out from 30 to 40 pounds of good quality, finely ground oak or hemlock bark and pour onto it about 20 gallons of boiling water.

Finely ground bark, with no particles larger than a grain of corn, will give the best results. Simply chopping the bark into coarse pieces will not do. Do not let the tan liquor come into contact with iron vessels. Use the purest water available. Rain water is best.

Let this bark infusion stand in a covered vessel until ready for use. Stir it occasionally. When ready to start tanning, strain off the bark liquor through a clean, coarse sack into the tanning barrel. Fill the barrel about three-quarters full with water, rinsing the bark with this water so as to get out as much tannin as possible. Add 2 quarts of vinegar. Stir well. Place the sides, from the deliming, over sticks, and hang them in this bark liquor with as few folds and wrinkles as possible. Move the sides about and change their position often in order to get an even color.

Just as soon as the sides have been hung in the bark liquor, again soak from 30 to 40 pounds of ground bark in about 20 gallons of hot water. Let this second bark liquor stand until the sides have become evenly colored, or for from 10 to 15 days. Take out of the tanning barrel 5 gallons of liquor and pour in about one-quarter of the second bark liquor. Also add about 2 quarts more of vinegar and stir it in well. Five days later take out a second 5 gallons of tanning liquor from the barrel and add another fourth of the tan liquor only (no vinegar). Do this every 5 days until the second bark liquor is used up.

The progress of the tanning varies somewhat with conditions and can best be followed by inspecting a small sliver cut from the edge of the hide. About 35 days after the actual tanning has been started a fresh cut should show two dark or brown narrow streaks about as wide as a heavy pencil line coming in from each surface of the hide.

At this stage weigh out about 40 pounds of fine bark and just moisten it with hot water. Do not add more water than the bark will soak up. Pull the sides out of the bark liquor and dump in the moistened bark, keeping in the barrel as much of the old tan liquor as possible. Mix thoroughly and while mixing hang the sides back in the barrel. Actually bury them in the bark. All parts of the sides must be kept well down in the bark mixture. Leave the sides in this bark for about 6 weeks and move them about once in a while.

At the end of 6 weeks pull the sides out. A cutting should show that the tanning has spread nearer to the center. Pour out about half the liquor. Stir the bark in the barrel, hang the sides back, and fill the barrel with fresh, finely ground bark. Leave the sides in for about 2 months, shaking the barrel from time to time and adding bark and water as needed to keep the sides completely covered.

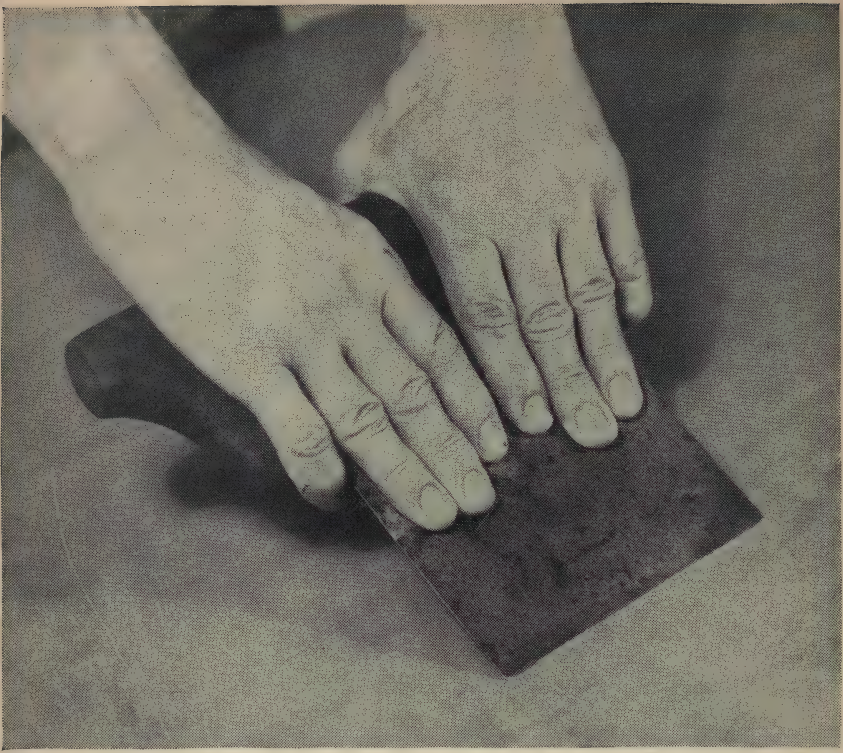

FIGURE 7.—Slicking out. After tanning and after greasing, the leather should be worked out on both sides with a slicker.

At the end of this time the hide should be evenly colored all the way through, without any white or raw streak in the center of a cut edge. If it is not struck through, it must be left longer in the wet bark, and more bark may be needed.

For harness, strap, and belting leather the sides may be taken out of the bark liquor at this stage, but for sole leather they must be left for 2 months longer. When fully tanned through, the sides are ready for oiling and finishing.

Oiling and Finishing

HARNESS AND BELTING LEATHER.—Take the sides from the tan liquor, rinse them off with water, and scour the grain or hair side thoroughly with plenty of warm water and a stiff brush. Then go over the sides with a "slicker" (fig. 1), pressing the slicker firmly against the leather while pushing it away from the body and work out as much water as possible. "Slick" out on the grain or hair side in all directions (fig. 7). For harness, belting, and the like this scouring and slicking must be done thoroughly.

A slicker can be made from a piece of copper or brass about one-fourth inch thick, 6 inches long, and 4 inches wide. One long edge of the slicker is mounted in a wooden handle and the other long edge is finished smooth and well rounded. A piece of hardwood, about

6 inches square, 1½ inches thick at the head, and shaved down wedge-shape to a thin edge will also serve as a slicker (fig. 1).

While the sides are still damp, but not very wet, go over the grain or hair side with a liberal coating of neat's-foot or cod oil. Hang up the sides and let them dry out slowly. When dry, take them down and dampen well by dipping in water or by rolling them up in wet sacking or burlap.

When uniformly damp and limber, evenly brush or mop over the grain or hair side a thick coating of warm dubbin. The dubbin is made by melting together about equal parts of cod oil and tallow or neat's-foot oil and tallow. This dubbin when cool must be soft and pasty, but not liquid.

Hang up the sides again and leave until thoroughly dry. When dry, scrape off the excess tallow by working over with the slicker. If more grease in the leather is desired, dampen again and apply another coating of the dubbin, giving a light application to the flesh side also. When again dry, remove the tallow and thoroughly work over all parts of the leather with the slicker. Rubbing over with sawdust will help to take up any surface oiliness.

If it is desired to blacken the leather, this must be done before greasing. A black dye solution can be made by dissolving one-half ounce of water-soluble nigrosine in 1¼ pints of water, with the addition, if handy, of several drops of ammonia. Evenly mop or brush this solution over the dampened but ungreased leather and then grease as directed in the preceding paragraph.

Sole Leather.—Take the sides from the tan liquor and rinse them thoroughly with clean water. Slick out on the grain or hair side as described for harness leather. Hang them up until they are only damp and then apply a good coating of neat's-foot oil or cod oil to the grain or hair side. Again hang them up until they are thoroughly dry.

When repairing shoes with this leather it is advisable, after cutting out the piece for soling, to dampen and hammer it down well, and then, after putting it on the shoe, to make it waterproof and more serviceable by setting the shoe in a shallow pan of melted grease or oil and letting it stand for about 15 minutes. The grease or oil must be no hotter than the hand can bear. Rubber heels should not be put in oil or grease. The soles of shoes with rubber heels may be waterproofed in the same way, using a piepan for the oil or grease and placing the heels outside the pan. Any good oil or grease will do. The following formulas have been found satisfactory:

	Ounces
Formula 1:	
Neutral wool grease	8
Dark petrolatum	4
Paraffin wax	4
Formula 2:	
Petrolatum	16
Beeswax	2
Formula 3:	
Petrolatum	8
Paraffin wax	4
Wool grease	4
Crude turpentine gum (gum thus)	2
Formula 4:	
Tallow	12
Cod oil	4

CHROME-TANNED LEATHER

For many purposes chrome-tanned leather is considered to be as good as the more generally known bark or vegetable-tanned leather. The chrome process, which takes only a few weeks as against as many months for the bark-tanning process, derives its name from the use of chemicals containing chromium. It is a chemical process requiring great care. It is felt, however, that by following exactly the directions here given, never disregarding details which may seem unimportant, a serviceable leather can be produced in a comparatively short time. The saving in time seems sufficient to justify a trial of this process.

Deliming

After the sides have been put through the unhairing and fleshing operations (p. 9) rinse them off with clear water.

If sole, belting, or harness leather is to be tanned, soak and wash the sides in cool water for about 6 hours before putting them into the lactic acid. Change the water four or five times.

If strap, upper, or thin leather is to be tanned, put the limed white sides into a wooden or fiber tub of clean, lukewarm (about 90° F.) water and let them stay there for from 4 to 8 hours before putting them into the lactic acid. Stir the sides about occasionally. Be sure that the water is not too hot. It never should be so hot that it is uncomfortably warm to the hand.

For each large hide or skin buy 5 ounces of U. S. P. lactic acid (or 16 ounces of tannery 22 percent lactic acid). Nearly fill a clean 40- to 50-gallon barrel with clean, cool water, and stir in the lactic acid, mixing thoroughly with a paddle. Hang the sides in the barrel, and leave them there for 24 hours, plunging them up and down occasionally.

For light skins, weighing less than 15 pounds, use only 2 ounces of U. S. P. lactic acid in about 20 gallons of water.

If lactic acid cannot be obtained, use 1 pint of vinegar for every ounce of lactic acid. An effort should be made to get the lactic acid, however, for vinegar will not be as satisfactory, especially for the medium and smaller skins.

After deliming, work over both sides of the side as directed under Unhairing (p. 9).

For sole, belting, and harness leathers, hang the sides in a barrel of cool water overnight. Then proceed as directed under Tanning.

For thin, softer leathers from small skins, do not soak the sides in water overnight. Simply rinse them off with water and proceed as directed under Tanning.

Tanning

The tanning solution should be made up at least 2 days before it is to be used—that is, not later than when the sides are taken from the limewater for the last time.

Remember that this is a chemical process and that all materials must be of good quality and accurately weighed and the specified quantities of water carefully measured.

The following chemicals are required: Chrome alum (chromium potassium sulfate crystals); soda crystals (crystallized sodium carbonate); and common salt (sodium chloride). Insist upon pure chemicals of the United States Pharmacopœia quality. Get them from the nearest drugstore or find out from it the address of a chemical manufacturing concern which can supply them.

For each hide or skin weighing more than 30 pounds use the following quantities for the stock chrome solution:

Dissolve 3½ pounds of soda crystals (crystallized sodium carbonate) and 6 pounds of common salt (sodium chloride) in 3 gallons of warm, clean water in a wooden or fiber bucket. The soda crystals must be clear or glasslike. Do not use the white crusted lumps.

At the same time dissolve in a large tub or half barrel 12 pounds of chrome alum (chromium potassium sulfate crystals) in 9 gallons of cool, clean water. This will take some time to dissolve and will need frequent stirring. Here again it is important to use only the very dark, hard, glossy, purple or plum-colored crystals of chrome alum, not the lighter, crumbly, dull-lavender ones.

When the chemicals are dissolved, which can be told by feeling around in the tubs with a paddle, pour the soda-salt solution slowly in a thin stream into the chrome-alum solution, stirring constantly. Take at least 10 minutes to pour in the soda solution. This should give one solution of about 12 gallons, which is the stock chrome solution. Keep this solution well covered in a wooden or fiber bucket, tub, or half barrel.

To start tanning, pour one-third (4 gallons) of the stock chrome solution into a clean 50-gallon barrel and add about 30 gallons of clean, cool water; that is, fill the barrel about two-thirds full. Thoroughly mix the solution in the barrel and hang in it the sides from the deliming. Work the sides about and stir the solution frequently, especially during the first 2 or 3 days. This helps to give the sides an even color. It should be done every hour or so throughout the first day. Keep the sides as smooth as possible.

After 3 days, temporarily remove the sides from the barrel. Add one-half of the remaining stock chrome solution, thoroughly mixing it with that in the barrel, and again hang in the sides. Move the sides about and stir the solution 3 or 4 times each day.

Three days later, once more temporarily remove the sides. Pour into the barrel the rest of the stock chrome solution, thoroughly mixing it with that in the barrel, and again hang in the sides. Move the sides about and stir frequently as before.

After the sides have been in this solution for 3 or 4 days, cut off a small piece of the thickest part of the side, usually in the neck, and examine the freshly cut edge of the piece. If the cut edge seems to be evenly colored greenish or bluish all the way through, the tanning is about finished. Boil the small piece in water for a few minutes. If it curls up and becomes hard or rubbery, the tanning is not completed and the sides must be left in the tanning solution for a few days longer, or until a small piece when boiled in water is changed little if at all.

The foregoing quantities and directions have been given for a medium or large hide. For smaller hides and skins the quantities of chemicals and water can be reduced. For each hide or skin weighing less than 30 pounds, or for two or three small skins together weighing not more than 30 pounds, the quantities of chemicals may be cut in half, giving the following solutions:

For the soda-salt solution, dissolve 1¾ pounds of soda crystals (crystallized sodium carbonate) and 3 pounds of common salt (sodium chloride) in 1½ gallons of clean water.

For the chrome-alum solution, dissolve 6 pounds of chrome alum (chromium potassium sulfate crystals) in 4½ gallons of cool, clean water.

When the chemicals are dissolved pour the soda-salt solution slowly into the chrome-alum solution as already described. This will give one solution of about 6 gallons which is the stock chrome solution. For the lighter skins tan with this solution, exactly as directed for medium and large hides, adding one-third, that is, 2 gallons, of this stock chrome solution each time, and begin to tan in about 15 gallons instead of 30 gallons of water. Follow the directions already given as to stirring, number of days, and testing to determine when tanning is completed. Very small, thin skins probably will not take as long to tan as will the large hides. The boiling-water test is very reliable for showing when the hide is tanned.

Washing and Neutralizing

When the sides are tanned, take them out of the tanning solution and put them in a barrel of clean water. The barrel in which the tanning was done can be used after it has been thoroughly washed.

When emptying the tanning barrel be sure carefully to dispose of the tanning solution. Although not poisonous to the touch, it probably would be fatal to farm animals should they drink it, and it is harmful to soil.

Wash the sides in about four changes of water. For medium and large hides, dissolve 2 pounds of borax in about 40 gallons of clean water and soak the sides in this solution overnight. For hides and skins weighing less than 25 pounds, use 1 pound of borax in about 20 gallons of water. Move the sides about in the borax solution as often as feasible. After soaking overnight in the borax solution, remove the sides and wash them for an entire day, changing the water five or six times. Take the sides out, let the water drain off, and proceed as directed under Dyeing Black, or, if it is not desired to blacken the leather, proceed as directed under Oiling and Finishing.

Dyeing Black

WATER-SOLUBLE NIGROSINE.—One of the simplest and best means of dyeing leather black is to use nigrosine. Make up the dye solution in the proportion of one-half ounce of water-soluble nigrosine dissolved in 1¼ pints of water. Be sure to get water-soluble nigrosine. Evenly mop or brush this solution over the damp leather after draining as already directed and then proceed as directed under Oiling and Finishing.

IRON LIQUOR AND SUMAC.—If water-soluble nigrosine cannot be obtained, a fairly good black may be secured with iron liquor and sumac. To make the iron liquor, mix clean iron filings or turnings with one-half gallon of good vinegar and let the mixture stand for several days. See that there are always some undissolved filings or turnings in the vinegar. For a medium or large hide put from 10 to 15 pounds of dried crumbled sumac leaves in a barrel containing from 35 to 40 gallons of warm water. Stir well and when cool hang in it the wet, chrome-tanned sides. If you cannot get sumac leaves, use 20 or 30 pounds of finely chopped oak or hemlock bark but pour hot water on the bark and let stand a couple of days before use. Leave the sides in this solution for about 2 days, pulling them up and mixing the solution frequently. Take out the sides, rinse off all bits of sumac, and evenly mop or brush over with the iron liquor. Rinse off the excess of iron liquor and put the sides back in the sumac overnight. If not black enough the next morning, mop over again with iron liquor, rinse, and return to the sumac solution for a day. Take the sides out of the sumac, rinse well, and scrub thoroughly with warm water. Finally wash the sides for a few hours in several changes of water.

While both of these formulas of dyeing have been given, it is recommended that water-soluble nigrosine be used whenever possible, as the iron liquor and sumac formula is somewhat troublesome and may produce a cracky grain. After blackening, proceed as directed under Oiling and Finishing.

Oiling and Finishing

Thin Leather.—Let the wet tanned leather from the dyeing, or, if not dyed, from the neutralizing, dry out slowly. While it is still very damp go over the grain or hair side with a liberal coating of neat's-foot or cod oil. While still damp, tack the sides out on a wall or tie them in frames (shown on cover), being sure to pull them out tight and smooth, and leave them until dry. When dry take down and dampen well by dipping in warm water or by rolling them up in wet sacking or burlap. When uniformly damp and limber go over the sides with a "slicker" (fig. 1), pressing the slicker firmly against the leather, while pushing it away from the body. Slick out on the grain or hair side in all directions (fig. 7).

After slicking it may be necessary to "stake" the leather (fig. 8). This is done by pulling the damp leather vigorously back and forth over the edge of a small smooth board about 3 feet long, 6 inches wide, and 1 inch thick, fastened upright and braced to the floor or ground. The top end of the board must be shaved down to a wedge shape, with the edge not more than one-eighth inch thick and the corners well-rounded (fig. 1). Pull the sides, flesh side down, backward and forward over this edge, exactly as a cloth is worked back and forth in polishing shoes.

Let the sides dry out thoroughly again. If not sufficiently soft and pliable, dampen them with water, apply more oil, and slick and stake as before. The more time given to slicking and staking, the smoother and more pliable the leather will be.

Thick Leather.—Thick leather from the larger hides is oiled and finished in a slightly different manner. For harness and strap leather, let the tanned sides, dyed if desired, dry down. While they are still quite damp slick over the grain or hair side thoroughly and apply a liberal coating of neat's-foot or cod oil. Tack on a wall or tie in a frame, stretching the leather out tight and smooth, and leave until dry. Take the sides down, dampen them with warm water until limber and pliable, and apply to the grain side a thick coating of warm dubbin. The dubbin is made by melting together about equal parts of cod oil and tallow or neat's-foot oil and tallow. When cool it must

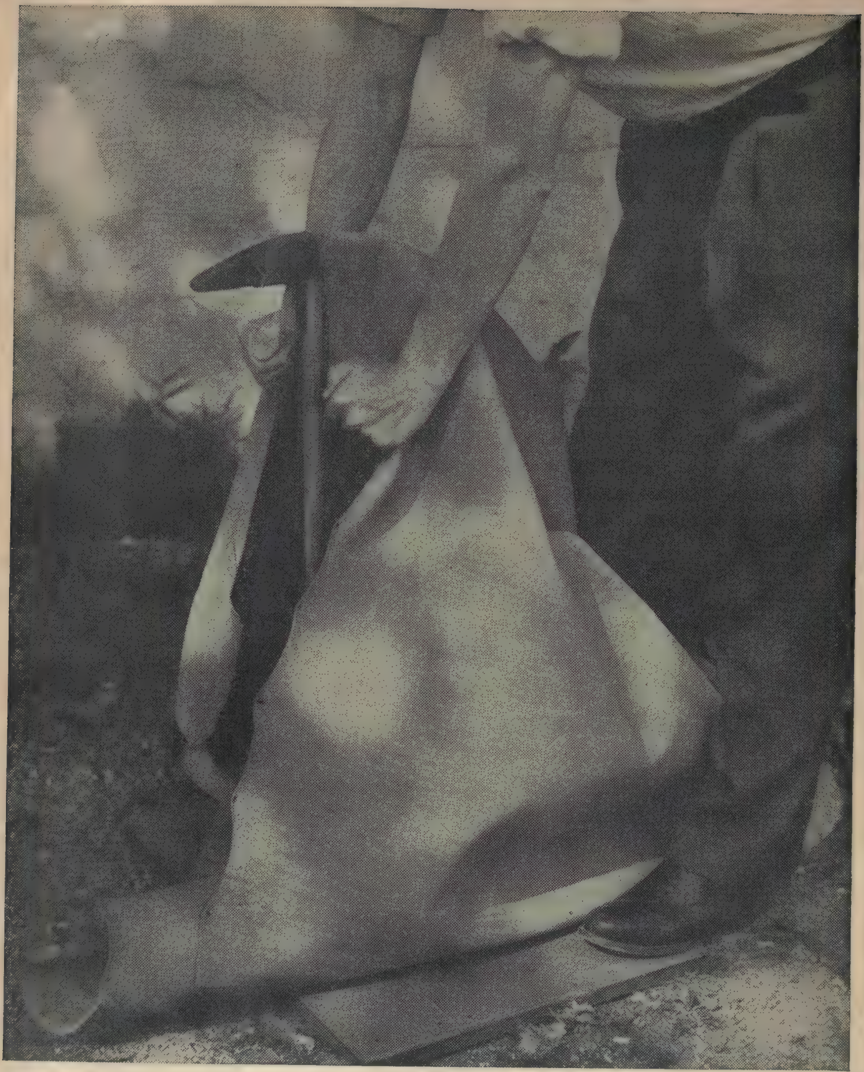

FIGURE 8.—Staking. To soften leather and tanned skins, work them repeatedly back and forth in all directions over a dull edge. This must be done when the leather is drying.

be soft and pasty but not liquid. If too nearly liquid, add more tallow. Hang up the sides again and leave them until thoroughly dried. When dry, scrape off the excess tallow by working over with the slicker. If more grease in the leather is desired, dampen again and apply another coating of the dubbin. When again dry, slick off the tallow and thoroughly work over all parts of the leather with the slicker. Rubbing over with sawdust helps to take up surface oiliness.

Chrome-tanned leather is stretchy, so that in cutting the leather for use in harness, straps, reins, and similar articles it is best to first take out most of the stretch.

Chrome leather for shoe soles must be heavily greased, or, in other words, waterproofed, unless it is to be worn in extremely dry regions. Waterproofing may be done after repairing the shoes by setting them in a shallow pan of oil or grease so that just the soles are covered by the grease. The soles should be dry before they are set in the melted grease. Melted paraffin wax will do, although it makes the soles stiff. The simple formulas given on page 13 are satisfactory for waterproofing chrome sole leather.

ALUM-TANNED LACE LEATHER

Deliming

After the sides have been put through the unhairing and fleshing operations (p. 9), rinse them off with cool, clean water for from 6 to 8 hours, changing the water frequently.

Buy 5 ounces of U. S. P. lactic acid (or 16 ounces of tannery 22 percent lactic acid). Nearly fill a clean 40- to 50-gallon barrel with clean, cool water and stir in the lactic acid, mixing thoroughly with a paddle. Hang the sides in the barrel and leave them there for 24 hours, pulling them up and stirring them about frequently. Take out the sides, work over or scud thoroughly, as directed under Unhairing (p. 9), and hang them in a barrel of cool water. Change the water several times, and finally leave them in the water overnight. If lactic acid cannot be obtained, use a gallon of vinegar instead.

Tanning

While the sides are being delimed, thoroughly wash out the barrel in which the hide was limed. Put in it 15 gallons of clean water and 12 pounds of ammonia alum or potash alum and stir frequently until it is completely dissolved.

Dissolve 3 pounds of washing soda (crystallized sodium carbonate) and 6 pounds of salt in 5 gallons of cold, clean water in a wooden bucket. The soda crystals must be clear and glasslike. Do not use white crusted lumps.

Pour the soda solution into the alum solution in the barrel very, very slowly, stirring the solution in the barrel constantly. Take at least 10 minutes to pour in the soda solution in a small stream. If the soda is poured in rapidly the solution will become milky and will not tan. The solution should be cool, and enough water to nearly fill the barrel should be added.

Hang each well-washed side from the deliming in the alum-soda solution. Pull up the sides and stir the solution six or eight times each day. Do not put the bare hands in the liquor if they are cut or cracked or have sores on them.

After 6 or 7 days remove the sides from the alum-soda solution and rinse well for about a quarter of an hour in clean, cold water.

Oiling and Finishing

Let the sides drain and dry out slowly. While still very damp go over the grain or hair side with a liberal coating of neat's-foot or cod oil. After the oil has gone in and the sides have dried a little more but are still slightly damp, begin to work them over a "stake." The time to start staking is important. The sides must not be too damp; neither must they be too dry. When light spots or light streaks appear on folding it is time to begin staking. Alum-tanned leather must be thoroughly and frequently staked.

Staking is done by pulling the damp leather vigorously back and forth over the edge of a small, smooth board (fig. 1), as described on page 17. The sides must be staked thoroughly all over in order to make them pliable and soft, and the staking must be continued at intervals until the leather is dry.

When dry, evenly dampen the sides by dipping them in water or by leaving them overnight covered with wet burlap or sacks. Apply to the grain or hair side a thick coating of warm dubbin. The dubbin is made by melting together about equal parts of neat's-foot oil and tallow or cod oil and tallow. When cool, the dubbin must be soft and pasty but not liquid. If too nearly liquid, add more tallow. Leave the greased sides, preferably in a warm place, until dry. Scrape off the excess tallow and again stake the sides. If the leather is too hard and stiff, dampen it evenly with water before staking.

After staking, go over the sides with a slicker (fig. 1), pressing the slicker firmly against the leather, while pushing it away from the body. Slick out on the grain, or hair side, in all directions (fig. 7).

Alum-tanned leather almost invariably dries out the first time hard and stiff. It must be dampened again and restaked while drying. In some cases this must be done repeatedly, and another application of dubbin may be necessary. By repeated dampening, staking, and slicking the leather can be made as soft and pliable as desired.

TANNING FUR SKINS

Much of the value of a fur skin depends upon the manner in which it is handled in the raw state. After the animal has been caught, every effort should be made to follow the best practices in skinning and curing, in order to obtain a skin of the greatest possible value. Certain trade customs also must be followed to secure the top price.

Requests for directions for tanning fur skins are constantly received by the Department of Agriculture. There is, however, less need for such information than there is for information on farm or home tanning of hides and skins into leather. Fur skins as a protection are a necessity for those living in cold climates, but comparatively few are used for this purpose. Most of the fur skins are made into articles which are more or less of a luxury and, as such, are valued largely on the basis of their appearance and finish, which an inexperienced worker can seldom make sufficiently pleasing. Furthermore, raw fur skins are valuable, and, if well cared for, usually find a ready market. Nevertheless, the spread between the prices paid for raw furs and those demanded for finished fur articles is enormous. No doubt, this spread in many instances inspires the attempts at home manufacture.

An inexperienced person should not try to tan valuable fur skins or large hides, such as cattle, horse, or bear, for making into coats, robes, or rugs. The risk of damage or of an unsatisfactory product, as measured by the usual standards of finish and appearance, is too great. The difficulties in properly handling large hides make the chances of success remote, except by those having suitable equipment

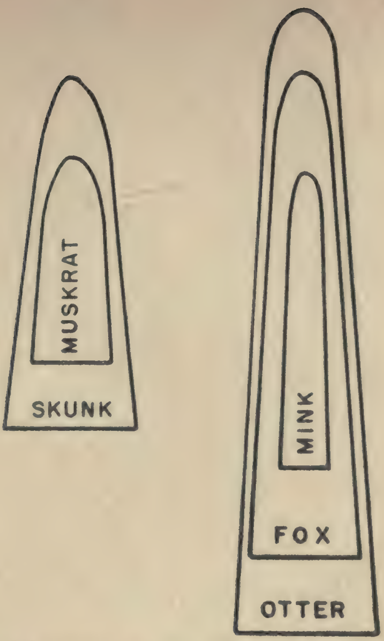

FIGURE 9.—Stretching boards for fur skins. Cased fur skins are dried on boards of different sizes and shapes, depending upon the kind of skin.

and experience. Moreover, tanning the skin is only one step in the production of the finished article. After being tanned, all skins must be tailored, many must be dyed, and small ones must be matched, blended, and sewed together. All these operations require experience and practice to secure the attractive appearance desired by wearers of furs. Some of the operations, such as those of bleaching and dyeing, are so highly specialized that their undertaking should not even be considered by an amateur. From the standpoint of serviceability and usefulness, inexperienced persons might meet with a fair degree of success in tanning and tailoring fur skins, but few can ever hope to make a fur piece or garment which will compare favorably in appearance with the shop or factory product. The tanning and dressing of fur skins, then, are best left to those who are experienced and equipped to carry out the tedious operations required.

To satisfy the demand upon the Department for information on the home tanning of fur skins and to provide those who insist upon carrying on such work with correct information and with detailed methods which offer the best chances for success, the following directions are given. These directions are meant primarily for small fur skins no larger than that of the fox and for skins of low market value.

No formulas for tanning are foolproof, and success can be attained only by close observation, plenty of work, and the exercise of care and patience. All skins are not treated just alike. In fact, each skin has its own peculiarities, which only experience can show how to treat. Some skins are tough and fairly thick and will stand mistreatment; others are very thin and tender and are easily ruined. Some are fat and greasy and require thorough working out of the grease;

others do not. An inexperienced person should experiment with the least valuable skins. If a number of skins of the same kind are to be tanned, one or two of the poorest should be tried first.

SOAKING AND FLESHING

The first step is to get the skin thoroughly softened, cleaned, and free from flesh and grease.

Split the tail the entire length on the underside. If the skin is "cased," split it neatly down the middle of the belly. Soak it in several changes of clear, cool water. When the skin begins to soften, lay it on a beam or smooth pole and begin working over the flesh side to break up the adhering tissue and fat. All dried skins have a shiny, tight layer of tissue. This tissue must be broken up and entirely removed, which is best done by repeated alternate working and soaking. A good tool for scratching the tissue is a metal edge of any kind, such as a drawing knife or an ordinary knife with dull saw teeth or notches filed in it. Working over with these dull teeth scratches or breaks up the tissue so that it can be scraped off after further soaking.

At the same time the grease and oil are worked out of the skin. This operation is of the utmost importance. It is utterly useless to start tanning until all the tissue and grease have been removed and the skin is uniformly soft and pliable, without any hard spots.

The time of soaking depends upon the condition of the skin. Some skins require only about 2 hours, while others need a much longer time. Very hard skins often must be thoroughly dampened, rolled up, fur side out, and put away in a cool place overnight to soften. While a skin must be soaked until soft, it should not stay wet longer than necessary, as the hair may start to slip.

In fleshing and scraping, care also must be taken not to injure the true skin or expose the hair roots, especially on thin skins.

When the soaking is well advanced and the skin is getting in good shape, work it in lukewarm water containing an ounce of soda or borax to the gallon. Soap also may be added. This treatment promotes softening, cleans the skin, and cuts the grease.

Work again over the beam and finally rinse thoroughly in lukewarm water. Squeeze out most of the water, but do not wring the skin. Without further drying, work the skin in gasoline, using several changes if very much dirt and grease are present. Squeeze and hang up the skin for a few minutes.

The skin should now be ready for tanning. When painting or pasting of the tan liquor on the flesh side only is included in the directions for tanning, it is best to dry out the hair or fur side first by working in sawdust. In this way any heating of the fur side while the skin is tacked out is avoided, as are also matting and stiffening of the fur. If while drying out the fur, the flesh side becomes too dry, it must be evenly dampened with a wet cloth before applying the tan liquor.

COMBINATION TANNAGE

A combination tannage is a combination of mineral and vegetable tanning. It has an advantage over the salt-acid or salt-alum processes in giving a soft and flexible skin, as well as a more lasting tannage.

One of the most popular and successful formulas for a combination tannage is given by M. C. Lamb.[2] A pasty mixture of alum, salt, gambier, and flour, with or without glycerin or olive oil, is made as follows: Dissolve 1 pound of aluminum sulfate and 1 pound of salt together in a small quantity of water. Dissolve 3 ounces of gambier or Terra Japonica in a little boiling water. (Instead of gambier, 3 or 4 ounces of finely powdered sumac leaves may be used.) Mix the two solutions and make up to 2 gallons with water. As this solution is used, mix it with enough flour to make a moderately thin paste. If the skin has a hard texture and lacks natural grease, thoroughly mix a little olive oil or glycerin with the paste.

Soak, soften, and clean the skin as previously described and tack it out flat and smooth, flesh side up. Apply from two to three coatings of the paste, depending upon the thickness of the skin. Only thick skins require three coatings. Each coating should be about one-eighth inch thick and should be applied at intervals of a day. Between applications the skin should be kept covered with sacking or paper. Scrape off most of the old coating before putting on a new one. After the last coating has been applied, spread out the skin uncovered or hang it up to dry slowly.

When practically dry, wash off the flour paste, rinse for several minutes in water containing an ounce of borax to the gallon, then in water alone. Squeeze out most of the water. Put the skin over a beam and slick it out well on the flesh side with the back of a knife or edge of a wooden slicker (fig. 1), thus working out most of the water (fig. 7). Again tack the skin out smoothly, flesh side up, and apply a thin coating of any animal fat, fresh butter, being particularly good, or a nondrying oil, such as neat's-foot, castor, or olive oil. Glycerin or a soap may be used instead of the grease or oil. If the skin originally was very greasy, it may not be necessary to apply any oil.

When nearly dry, but still slightly damp, begin to work the skin in all directions, stretching it from corner to corner and working the flesh side over a stake (fig. 1) or a wooden edge, such as the back of a chair or piece of board clamped in a vice.

The time to begin working is important and is best judged from experience. The skin must not be too wet; neither must it be too dry. The appearance of a few light spots or a light streak on folding is a good indication of the time to start working the skin.

Work the skin in all directions back and forth, as if shining shoes with a cloth. The skin may also be worked this way through smooth metal rings. Much of the success in getting a soft skin lies in this repeated working, which must be done while the skin is drying out, not after it is dry. If the skin is not soft enough when dry, it must be evenly dampened and worked again while drying. This may be repeated several times if necessary.

After softening and drying out it is well to give the skin a hasty bath in gasoline. If the skin is greasy, this must be done. This also helps to deodorize some skins, such as those of the skunk.

Finally, to clean and brighten the tanned skin, tumble or work it repeatedly in dry, warm sawdust, preferably hardwood sawdust, or bran or cornmeal. Clean these out of the fur by gentle shaking, beating, combing, and brushing.

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[2] Leather Trades Review, August 20, 1913, p. 596.

The flesh side may be smoothed if necessary by working over a sandpaper block. This also helps to soften the skin further. If desired, the thicker sections of the skin may be made thinner and more flexible by shaving off some of the skin or hide.

SALT-ALUM TANNAGE

The salt-alum process, an old method for furskin tanning, is widely used. It is considered slightly better than the salt-acid tannage, being a little more permanent and, when properly carried out, giving skins which have a little more stretch and flexibility. It often happens, however, that alum-tanned skins come out stiff and hard and must be worked repeatedly and sometimes retanned.

A salt-alum tanning solution may be made up using the following proportions: 1 pound of ammonia alum or potash alum dissolved in 1 gallon of water; 4 ounces of washing soda (crystallized sodium carbonate) and 8 ounces of salt, dissolved together in one-half gallon of water. When dissolved, pour the soda-salt solution very slowly into the alum solution while stirring vigorously.

A skin, cleaned and softened as previously described, may be tanned by immersion in this solution for from 2 to 5 days, depending upon its thickness. Because of the action of alum on some furs it may be best, as a general rule, to apply the tanning liquor as a paste to the flesh side only.

Mix the tan liquor as used with sufficient flour to make a thin paste. Add the flour in small quantities with a little water and mix thoroughly to avoid lumps. Tack the skin out smoothly, flesh side up. Apply a coating of the paste about one-eighth inch thick and cover the skin. The next day scrape off most of the paste and give another coating. Apply altogether, at intervals of a day, from two to three coatings, depending upon the thickness of the skin. Only thick skins should need as many as three treatments. Leave the last coating on for 3 or 4 days. Finally scrape off and rinse clean in water, putting in about an ounce of borax to a gallon of water. Rinse at last in water only.

Work over a beam to remove most of the water. Stretch the skin out flat and sponge over the flesh side with a thin soap paste. After this has gone in, apply a thin coating of oil. Leave the skin stretched out to dry, and while it is still damp, work and stake as described on page 23, wetting and working repeatedly if necessary. Finally, clean in gasoline and sawdust and finish as described above.

SALT-ACID TANNAGE

One of the oldest processes of tanning requires various mixtures of common salt and sulfuric acid. Tanning, or, more correctly speaking, tawing, by this means is open to the objection that sulfuric acid must be used very cautiously, and must be completely neutralized to prevent later damage to the skin. Skins tanned with salt and acid also show a tendency to become damp and clammy in wet weather and, if repeatedly subjected to wetting, lose their tanned effect.

A salt-acid tanning solution may be made up in the following proportions: For each gallon of water use 1 pound of common salt and one-half ounce of concentrated sulfuric acid. Dissolve the salt and carefully pour in the acid while stirring. This tan liquor must be made and used in jars or wooden vessels, never in metal containers of any kind. (When pouring in the acid, do not inhale any more of the fumes given off than is necessary, and also be careful not to get any of the strong acid on the skin or clothing.) As soon as the acid-salt solution has cooled, it is ready for use.

Put the cleaned, softened skin in the solution so that it is entirely covered and leave it for from 1 to 3 days, depending upon its thickness. During this time stir the skin about frequently. If desired, the solution may be painted on instead. In this case, tack out the skin smoothly, flesh side up, paint over with the solution, and cover the skin with well-dampened sacking or cloth. At the end of 6 hours, paint over it again. With thicker skins, give one or two more applications of the solution about 6 hours apart, keeping the skin covered between applications. After the last application, hang up the skin or spread it, flesh side up, without cover, and let it dry.

After tanning, either by immersion or by painting, rinse the skin in clear water and squeeze out most of the water, but do not wring it. Then work the skin for about 10 minutes in a solution made up in the proportion of an ounce of borax in a gallon of water, and finally rinse well in clear water and squeeze.

Work over the skin with a slicker (fig. 1) to remove most of the water, tack it out flat, flesh side up, and apply a thin coating of grease or oil. Leave the skin stretched to dry, and while it is still damp work and stake it as described on page 23.

Finally clean in gasoline and sawdust, and finish by shaking, beating, sandpapering, brushing, and combing.

U.S. GOVERNMENT PRINTING OFFICE: 1962

CHECK up on these accident hazards around your farm . . .

- √ Is farmyard clear of tools, broken glass, loose strands of barbed wire, nail-studded boards?
- √ Are water tanks, cisterns, and wells protected?
- √ Are ladders and steps in good repair?
- √ Are pitchforks, rakes, shovels, and other sharp tools kept in racks?
- √ Are electric circuits and appliances in good condition?
- √ Is unused lumber carefully stacked?
- √ Are buildings and fences in good repair?

clean up your farm

to make it attractive and SAFE

U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1344

The STRAWBERRY ROOTWORM AS AN ENEMY OF THE GREENHOUSE ROSE

1862 1889

THE STRAWBERRY ROOTWORM or leaf-beetle has, in the last seven or eight years, become a destructive enemy of the greenhouse rose in all the commercial rose-growing districts east of the Rocky Mountains.

The grubs of this insect devour the tender rootlets and girdle the larger roots of the rose plants, while the beetles eat the leaves and succulent bark. In a house that is heavily infested, the beetles in a single night may destroy the "eyes" of all the cut-back plants. Heavy losses due to such injuries have been reported from all the large rose-growing regions except the Pacific coast.

This bulletin describes the strawberry rootworm in the four stages of its development, and gives an outline of measures to be used to control it when it appears in the rose house.

Washington, D. C. July, 1923

THE STRAWBERRY ROOTWORM AS AN ENEMY OF THE GREENHOUSE ROSE.

C. A. WEIGEL, *Entomologist*, and C. F. DOUCETTE, *Junior Entomologist, Greenhouse Insect Investigations, Bureau of Entomology.*[1]

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A NEW ENEMY OF ROSE.

ALTHOUGH the strawberry rootworm[2] or leaf-beetle has achieved much notoriety among florists because of its recent attacks in rose houses, it is doubtful whether all rose growers fully comprehend the destruction which this insect can inflict. During the last 40 years or more it has attained some prominence as an enemy of strawberry and raspberry, and also feeds on apple, peach, black walnut, butternut, and other species. It is a native beetle which occurs out of doors generally throughout the United States, but only in the last seven or eight years has it appeared in the greenhouses. Strangely, in this time it has been found injuring the forced rose plants in widely separated localities, namely, in Missouri, Massachusetts, Indiana, Louisiana, Maryland, Michigan, New Jersey, Pennsylvania, Rhode Island, Virginia, and the District of Columbia. In fact, all the commercial rose-growing districts in the United States east of the Rocky Mountains are affected and have suffered from the invasions of this insect, which the rose grower now finds it necessary to combat relentlessly.

CHARACTER OF INJURY.

Injury is done by the larvæ, or grubs, and by the beetles. Almost every part of the plant above ground is subject to attack by the beetles. The "shot-hole" appearance of the injured leaves (Fig. 1), which is very characteristic, completely destroys their ornamental value. The beetles also eat the green succulent bark of the forced plants, particularly in crotches, scarring and often girdling the stems. (Fig. 2.) The most serious injury to the plants occurs when they are "cut-back," for at this time the beetles devour the breaking "eyes" in the absence of the foliage. It is on these "eyes" that the florist depends for the development of his future crop, and their destruction means a very serious retardation of the growth and a loss in financial returns. In a single night the beetles in a heavily infested house can eat the heart out of practically every "eye," which means that the plant must spend a period of from six to eight weeks or more in developing a new growth of buds at a time when its vitality should be used in producing new canes and foliage. When present in large numbers the beetles feed upon the flower buds (Fig. 3) and render them unsalable.

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[1] The work upon which this bulletin is based was done in cooperation with the Bureau of Plant Industry of the Pennsylvania Department of Agriculture, Prof. J. G. Sanders, Director.

[2] *Paria canella* vars. *quadrinotata* Say and *gilvipes* Crotch. Order Coleoptera, family Chrysomelidae.

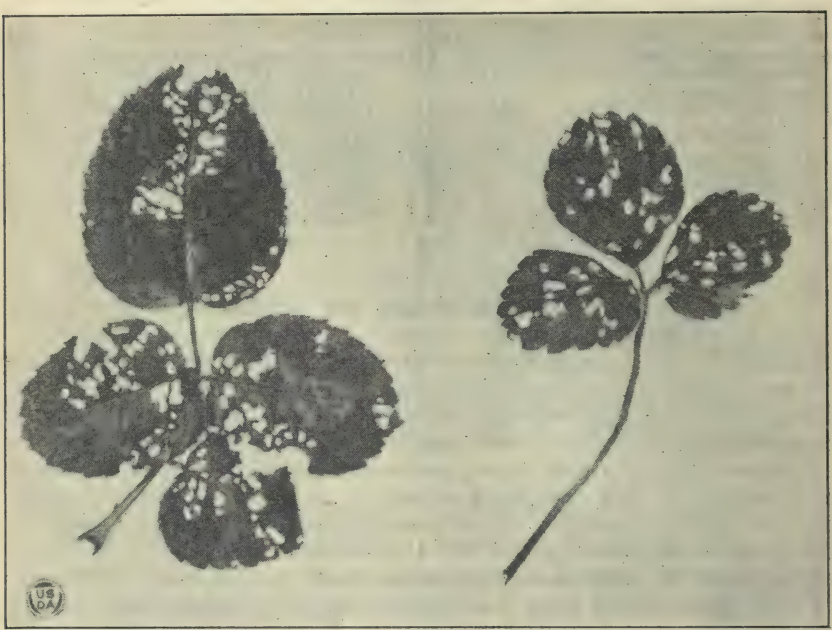

FIG. 1.—Characteristic "shot-hole" feeding punctures made by adults of the strawberry rootworm in foliage of rose and strawberry.

The grubs work in a more insidious manner, and their injuries to the plant may escape notice for a long time. Living in the soil as they do, the roots of the plants furnish their food. They not only devour the young tender rootlets but also girdle and gnaw into the stronger ones, even the main roots, thus interfering with the normal functioning of the root system. (Figs. 4 and 5.) The plants become weakened after two or three seasons of the root injury, have a "sickly" appearance, and many fail to respond after the "cutting-back" period. Furthermore, the many wounds in the plants, both on the roots and on the bushes above the ground, furnish just so many places where the microscopic organisms responsible for rose diseases may find entrance to the plant tissues. Some of these diseases known only too well by the grower are black spot, mildew, crown canker, and crown gall.

ECONOMIC IMPORTANCE.

The vast number of strawberry leaf-beetles which may be present in an infested greenhouse is well illustrated by the experience of one grower who hired several schoolboys to pick the beetles from the plants by hand. For several weeks many thousands of beetles were turned in, as many as 60,000 being collected in one week, the cost of which at 25 cents per 100 beetles amounted to $150. In spite of the destruction of so many beetles, there still seemed to be just as many feeding on the plants. The accounts of another florist showed his gross income per plant in a house of 7,000 plants to be $0.74 for the period from July 1, 1919, to February 1, 1920, as compared with the income of $1.17 for the same period in the preceding year. This decrease of $0.43 per plant,

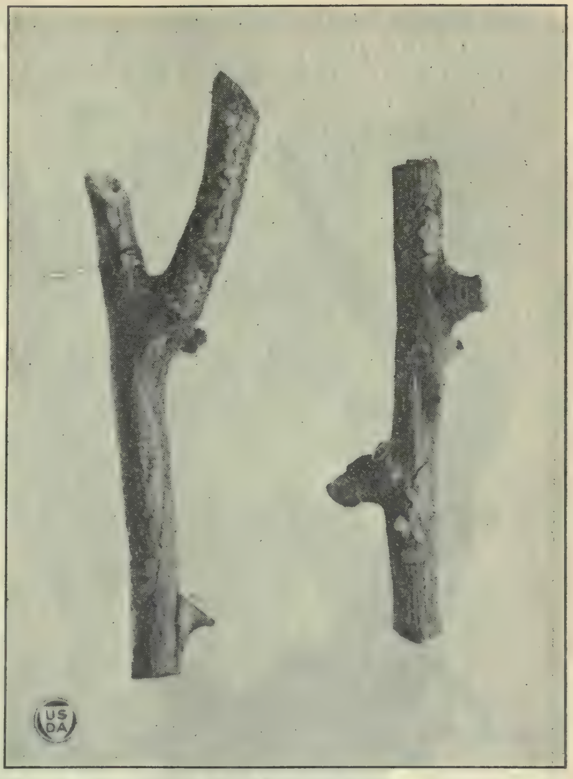

FIG. 2.—Rose stems scarred by the feeding of adults of the strawberry rootworm.

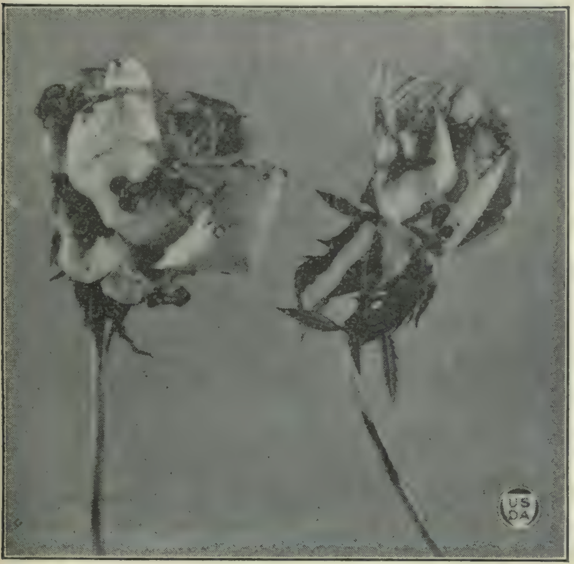

FIG. 3.—Rosebuds ruined by beetles of the strawberry rootworm.

or over $3,000 for the whole house, was due almost entirely to the ravages of this insect. A loss of $70,000 for the year 1920 is the estimate of florists in Bucks and Montgomery Counties, Pa. Similar reports of heavy infestations resulting in severe injury and serious financial loss have been received from all the large rose-growing sections except the Pacific coast region.

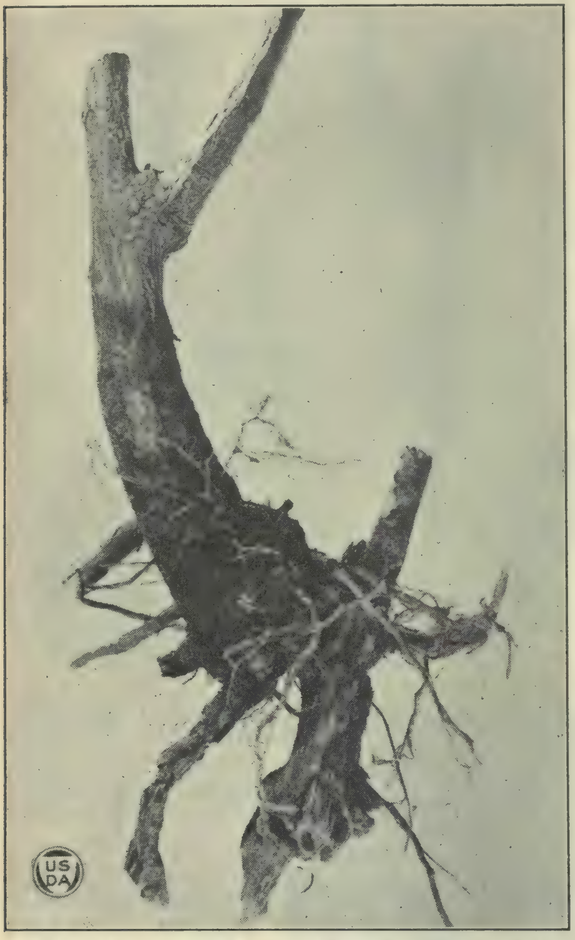

FIG. 4.—Root system of rose plant devoid of rootlets and with main roots severely injured by the feeding of grubs of the strawberry rootworm.

DEVELOPMENT AND HABITS.

There are four distinct and quite different stages (Fig. 5) in the life of the strawberry rootworm, namely, the egg, the larva or grub, the pupa, and the beetle.

THE EGG.

The eggs (Fig. 6), which are about one-thirtieth of an inch long and one-fourth as wide, light cream yellow, and long narrow oval, are laid in groups of from 2 to 10 on dead and dried leaves. The leaves may drop to the ground before the eggs hatch or may be washed from the bushes by syringing. Hatching usually occurs from 7 to 15 days after the eggs are laid, shorter periods occurring during the warmer months.

THE LARVA OR GRUB.

After emerging from the egg, the very tiny larva crawls off (Fig. 5) the leaf and, if the leaf is still on the plant, drops to the ground. With a peculiar spiral-like motion, it immediately burrows into the soil, where, during its development, it feeds upon all parts of the root system. (Figs. 4 and 5.) The larvæ do not come to the surface at any time. The number which may be found around the

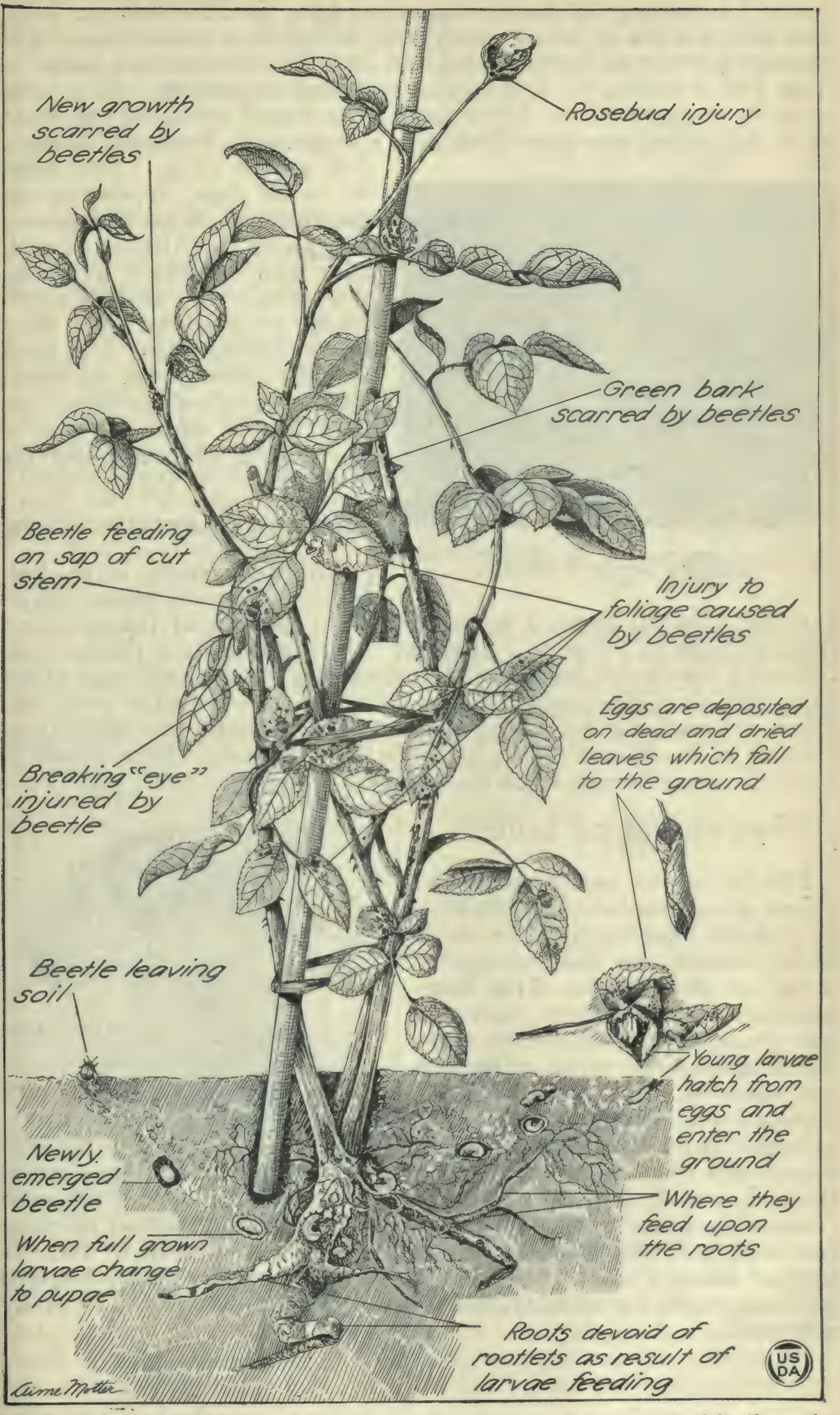
New growth scarred by beetles
Rosebud injury
Green bark scarred by beetles
Beetle feeding on sap of cut stem
Injury to foliage caused by beetles
Eggs are deposited on dead and dried leaves which fall to the ground
Breaking "eye" injured by beetle
Beetle leaving soil
Young larvae hatch from eggs and enter the ground
Newly emerged beetle
Where they feed upon the roots
When full grown larvae change to pupae
Roots devoid of rootlets as result of larvae feeding
US DA
Aime Motter

FIG. 5.—Stages in life history of the strawberry rootworm and injury caused by the grubs and beetles.

roots of a single plant is often so astonishing that the observer wonders that the plant is not completely killed in a short time. The average number of larvæ to a plant in a heavily infested house is from 4 to 6 during the late spring and summer months. In several cases 20 or more of the larvæ have been found infesting the roots of an individual rose plant from 5 to 7 years old. The grub becomes full grown (Fig. 7) in from 35 to 60 days, depending on the weather. When full grown it is about one-fifth of an inch long and one-third as wide, resembling very much a small white grub (larva of a May beetle) of that size. The head is light brown and the mandibles, or chewing jaws, are dark brown, while the rest of the body is white and slightly arched.

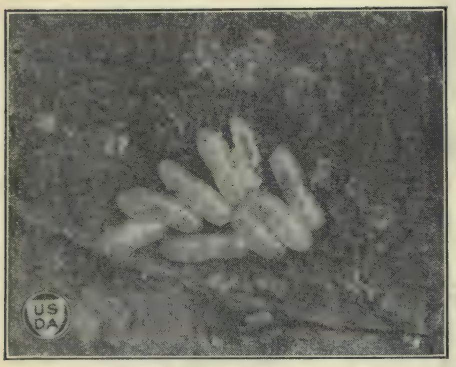
FIG. 6.—An egg mass of the strawberry rootworm on a portion of dead leaf.

THE PUPA OR RESTING STAGE.

The full-grown larva hollows out a small round cell in a pellet of earth about 2 inches below the surface of the soil, and there changes to the pupa. (Fig. 8.) During this stage the insect is normally very quiet, but when disturbed will wave its abdomen about very actively. The pupa is white, a little shorter than the grub, and bears several long hairs and hooks which prevent the body from coming in direct contact with the walls of its cell. After about 10 days the transformation to the beetle is complete.

THE BEETLE OR ADULT.

The florist will easily notice the brown shiny beetles (Fig. 9) with four darker brown spots on their backs feeding on the foliage or stems of the plants. The four-spotted form is more common, but occasionally there occur some which are black-bodied, with legs and antennæ, or feelers, of pale yellow, and the reddish head on both varieties will be seen on close examination. The beetle feeds mostly at night or on cloudy days, hiding among the foliage or in the surface mulch during the day. If disturbed it folds up its legs close to the body and drops to the ground, where it plays "possum" for some time. When the insect drops to the ground in this fashion its color blends so well with that of the soil that it is most difficult to find. A puff of tobacco smoke blown on the spot where the beetle dropped will bring it to life quickly, however, and as it moves it will be easily observed.

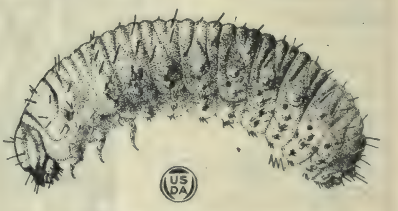
FIG. 7.—The strawberry rootworm larva or grub. Enlarged.

A female beetle lays eggs during a period of about three months and may deposit as many as 200. There is thus a continuous rearing of progeny, so that no definite broods are apparent. While several individuals have been known to live almost an entire year, the normal life of the beetle is probably about 100 days.

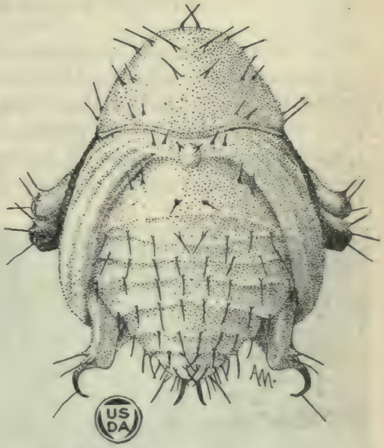

FIG. 8.—Pupa of the strawberry rootworm. Enlarged.

SEASONAL HISTORY.

Many of the adults which emerge in September and October spend the winter hiding in the mulch or soil or in dead leaves, occasionally coming out to feed when the days are clear and warm. After early February they are found on the plant more frequently, and the females begin laying eggs the latter part of February, continuing to do so through March and April. A few beetles continue to lay eggs during May and June as well. The individuals which develop from these eggs begin to appear in May and are present in large numbers during June and July. During the latter two months many eggs are laid, and the full-grown beetles which develop from them appear in September and October and live through the winter.

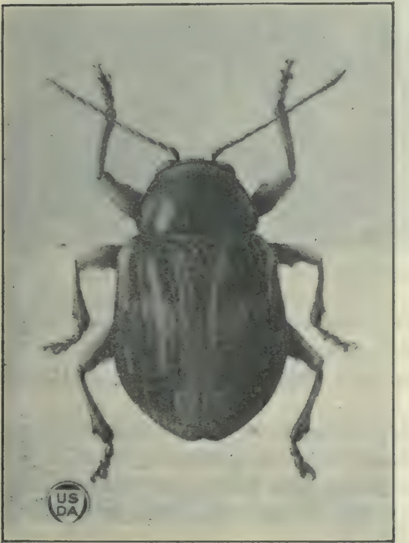

FIG. 9.—Beetle of the four-spotted variety of the strawberry rootworm. Enlarged.

HOW TO CONTROL THE PEST.

The methods ordinarily used to combat leaf-feeding insects out of doors have been found by both florists and entomologists to be unsatisfactory in checking the ravages of this pest in the greenhouse. Just as the culture of the rose in greenhouses is much more intensive than ordinary agricultural methods out of doors, the control measures must be highly specialized and very much more thorough than when used against common pests. The florists, therefore, can not rely on any one method alone to reduce materially an infestation of the strawberry rootworm, but must wage relentless warfare with all available means. Those recommendations for control which have been adopted are best suited to the florists' cultural methods and are aimed at the vulnerable points in the life history and habits of the insect. Success in controlling infestations will depend very largely upon the thoroughness and persistence of the treatments.

HYDROCYANIC-ACID GAS FUMIGATION.

The most efficient manner of killing the adults is by the use of hydrocyanic-acid gas. Used at the rate of 1½ to 2 ounces of sodium cyanid to each 1,000 cubic feet of space, the gas will kill practically every beetle above the ground. At this strength the gas also will injure the tender growth of roses and, therefore, can be utilized in the drying-off period only. Since the beetles are most numerous during the summer, when the florists rest their plants, it is seen that this is really the most favorable time for hydrocyanic-acid gas fumigation, as the control operation readily fits in with the cultural practice.

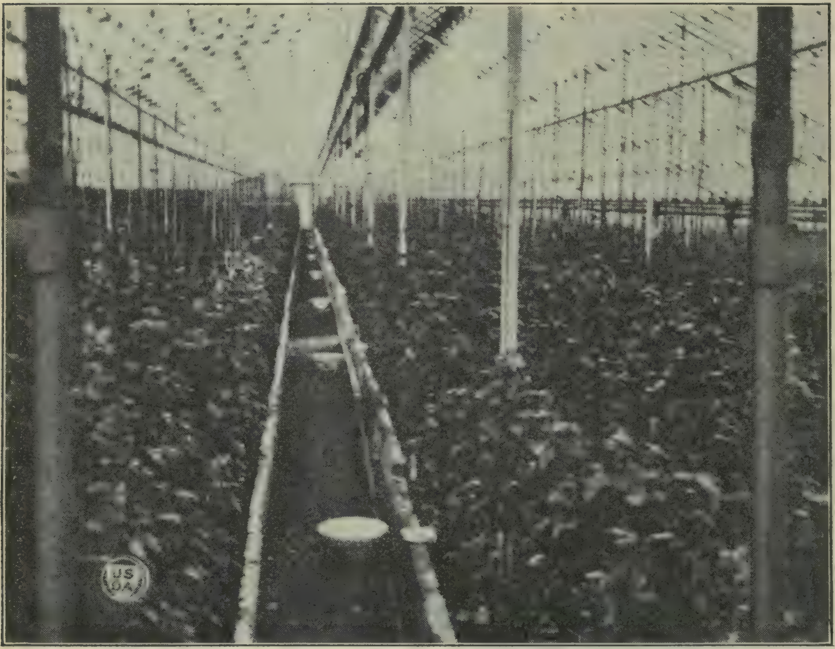

FIG. 10.—Greenhouse prepared for fumigation with hydrocyanic-acid gas.

Before the plants are cut back they should be subjected to three or more successive fumigations at intervals of three or four days, and the last exposure should take place the night preceding the cutting back. The materials to be used for every 1,000 cubic feet of space in the greenhouse are as follows:

Sodium cyanid	ounces (avoirdupois)	1½ to 2
Sulphuric acid	ounces (fluid)	2¼ to 3
Water	do	4½ to 6

For each ounce avoirdupois of sodium cyanid (containing approximately 51 per cent cyanogen), 1½ fluid ounces of sulphuric acid (1.83 specific gravity), and 3 fluid ounces of water have been used by the writers. This is a slight divergence from the formula generally accepted, owing to the necessity of securing sufficient dilute acid to submerge the cyanid. Under greenhouse conditions it is necessary to use a number of generators in order to secure an equal distribution of the gas, and as this number is increased the amount of chemicals in each generator is proportionately decreased, which will result in poor generation unless there is a slight excess of water. If it were possible to have a number of small generators considerably constricted inside at the bottom it would be possible to get a satisfactory generation of the gas with the usual 1–1½–2 formula.

To obtain the most successful results, the fumigating must be done *at night* and the greenhouse must be kept closed for two hours. (Fig. 10.) Under these conditions no regard need be had for the temperature. Practically every adult above ground will be found dead the following morning. It is again emphasized that roses can be safely fumigated during the resting period at the rate of 2 ounces of sodium cyanid per 1,000 cubic feet of space, whereas in the forcing period one-half ounce may cause considerable injury under unfavorable conditions. Therefore at the 2-ounce strength the gas can not be used in a house where plants are being forced, unless the grower is willing to accept the injury that will result. It is strongly recommended that houses be given the "drying" treatment as a whole and not in sections. Any portion of an open range of houses may be satisfactorily separated by the use of canvas or muslin curtains (Figs. 11 and 12) or oiled paper, thus solving a serious problem of the past in construction of this type. Further directions for fumigating greenhouses with hydrocyanic-acid gas are given in Farmers' Bulletin 880.

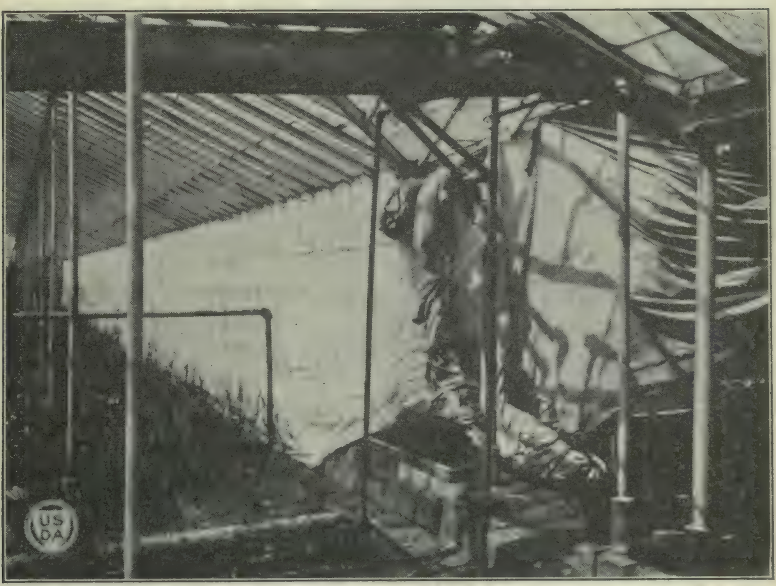

FIG. 11.—Muslin curtains used to separate sections of an open range of greenhouses during fumigation with hydrocyanic-acid gas.

SCRAPING SOIL OF BEDS.

Immediately after the tops are cut from the plants and removed, the dry surface layer of soil to a depth of 1 or 2 inches should be carefully scraped from the beds and taken a safe distance away from the greenhouses. This layer of soil contains many adults, and the shaking of the tops when they are being cut causes many others to drop and hide in it until night. To be effective the scraping must be done the same day that the tops are cut off, otherwise the beetles will come out of hiding in the evening and when they find no foliage left to eat will devour the "eyes" and girdle the stems. The florist may replace the soil according to his own cultural methods. Preferably the plants should be given their first heavy watering before the new soil is brought in, and well composted soil should be used.

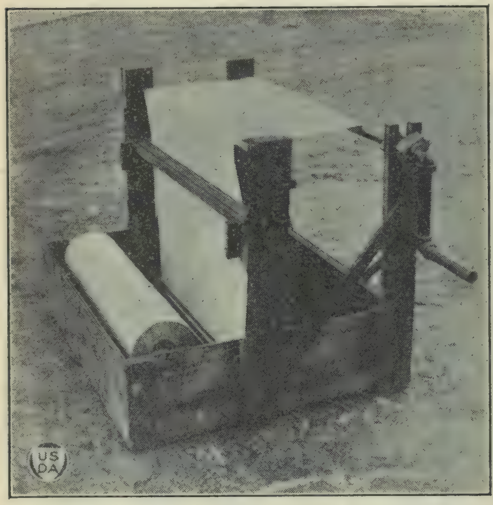

FIG. 12.—Method of preparing oiled paper which may be used instead of muslin to separate sections of an open range of greenhouses during fumigation with hydrocyanic-acid gas.

SPRAYING WITH ARSENICALS.

Immediately after the plants are cut back, the tops carried away, and the surface layer of soil removed, the plants should be sprayed with either lead arsenate or calcium arsenate. This also should be done the same day that the plants are cut back, so that any beetles coming from hiding places will find every portion of the plant protected. The arsenical should be mixed in the following proportions:

Lead arsenate or calcium arsenate (dry)	pounds	4
Water	gallons	50
Soap (for sticker)	pounds	2

The stems should be sprayed so thoroughly with the solution that all portions are covered completely and should present a whitewashed appearance. The spray may be mixed in a large tub or tank and applied by means of compressed-air sprayers.

TREATMENT WITH KEROSENE NICOTINE OLEATE.[2]

During the last few years a new contact insecticide has been developed by the formation of a soap or soaplike salt by the union of nicotine and commercial oleic acid (red oil), which when combined is known as nicotine oleate. It may be prepared from any nicotine preparation containing free nicotine. It dissolves in soft water, forming a soapy solution, which may be used to emulsify an animal, vegetable, or mineral oil.

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[2] Moore, William. A promising new contact insecticide. Journal of Economic Entomology, volume 11, No. 3, pp. 341, 342. June, 1918.

When the plants are watered heavily a brief syringing of the foliage knocks the beetles from the bushes into the pools and puddles of surface water. Filming the surface of these pools with kerosene nicotine oleate will kill the beetles as they swim through it. This material is mixed as follows:

STOCK EMULSION.

Solution 1:	
Kerosene	8 parts or 1 gallon.
Oleic acid	1 part or 1 pint.
Solution 2:	
Volatile or free nicotine, 40 per cent solution	2 parts or 2 pints.
Water	8 parts or 1 gallon.

Solution 1 is prepared by slowly pouring the oleic acid into the kerosene, stirring constantly. In another vessel make up Solution 2 by adding the nicotine solution to the water. The stock emulsion is then prepared by stirring Solution 1 into Solution 2, and the mixture is brought to a creamy consistency by rapidly churning it for several minutes, pouring from one vessel to the other or pumping the liquid back upon itself through a bucket pump.

Use 1 pint of the stock emulsion to 4 gallons of water and apply to the flooded beds by means of a sprinkling can, so that a film of the material covers the whole surface of the water. Those periods when the beetles are numerous, particularly September and October, are the favorable times for successful use of this treatment.

DUSTING WITH ARSENICALS.

After the middle of February, when the beetles begin to appear and are wont to feed upon the foliage, a coating of an arsenical should be maintained over the whole plant. Since the adults are present and feed at all times during the spring and summer until about November, continual applications of these materials during this period are necessary. The mixture used should contain at least 10 per cent of either lead arsenate or calcium arsenate, and preferably 15 per cent. The following formulæ are recommended. The florist may purchase them ready prepared or he may mix them himself.

Formula 1:		
Superfine sulphur (200 mesh)	pounds	90
Lead arsenate or calcium arsenate	do	10
Formula 2:		
Superfine sulphur (200 mesh)	do	85
Lead arsenate or calcium arsenate	do	15

When applied by means of the improved hand dusters of either the fan type (Fig. 13) or the bellows type (Fig. 14) now on the market, 8 pounds of the dust will cover the foliage and stems of 3,000 plants 2 or 3 feet tall. This number of plants can be dusted in from five to eight minutes.

The florist will find this material very easy to apply, and as it readily washes off the foliage it will not impair the value of the cut flowers. Because it washes off the foliage, it is necessary to dust the plants after every syringing, in order to maintain the coating of poison. This frequency of application, however, will keep all the new growth well covered and protected from the ravages of the beetles. Also the sulphur in the mixture will be of considerable value in keeping in check such leaf diseases as mildew and black spot.

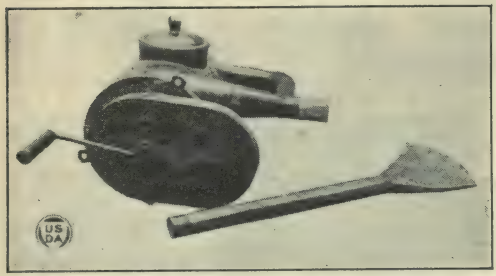


FIG. 13.—Fan type of hand duster used in applying insecticidal dusts in greenhouses.

TREATING WITH TOBACCO DUST AND WOOD ASHES.

The value of tobacco dust and wood ashes as fertilizers has long been recognized by florists, but there is some insecticidal effect as well in both. Experiments have shown that the newly hatched larvæ of the strawberry rootworm are killed when they come in contact with tobacco dust. As the larvæ are hatching almost continuously from March to September, the surface of the beds should be kept covered with this material to prevent the larvæ from entering the soil. Applications every two weeks will be sufficient if the dust is carefully spread over the entire surface. It must not be forgotten that a bare spot permits an entrance to the soil for the little grubs. Tobacco dust containing not less than one-half of 1 per cent nicotine should be used. The rose plant can not stand a very heavy application of wood ashes, and a handful of this material to each plant every two or three weeks will suffice. The continuous leaching of tobacco dust and wood ashes will help in reducing an infestation by destroying many of the larvæ and pupa in the soil.

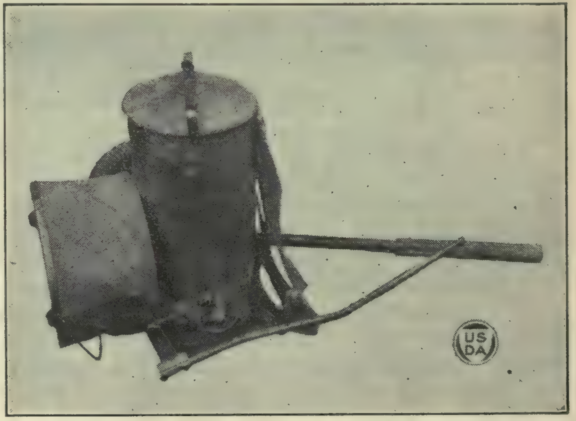


FIG. 14.—Bellows type of hand duster used in applying insecticidal dusts in greenhouses.

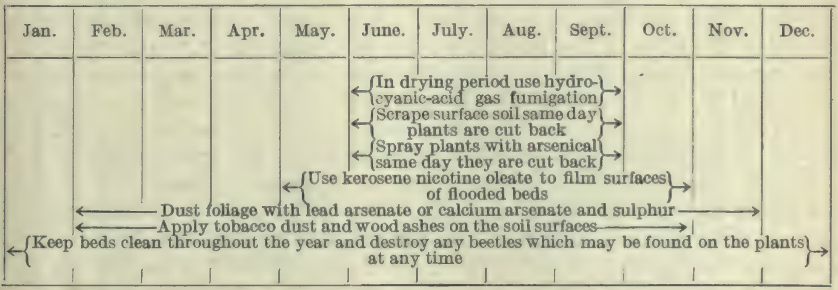
CLEAN CULTURE AND HAND PICKING.

The florist should at all times keep the beds free from dead leaves and other débris, which furnish hiding places for the strawberry rootworm adults and in which many eggs are laid. All such material removed during the winter months will carry away a considerable number of beetles and, therefore, will preclude their laying eggs in the spring. From February to September the removal of all dead leaves every 10 days at most will prevent access to the soil of any larvæ which may hatch from eggs in the leaves. When the beetles are very numerous in a greenhouse, the florist should forego any mulching with manure and feed the plants with manure water instead. Working among the plants every day, caring for the individual needs of each plant, the grower soon acquires the habit of killing every beetle he encounters on the leaves, buds, stakes, or wires, and persistent destruction in this manner will help materially in reducing infestations. As many beetles as possible should be destroyed during the fall and early spring, to reduce the number of overwintering beetles which lay eggs from February to June.

CONTROL PROGRAM.

In the accompanying chart the various recommendations for control are entered according to the periods when each may be successfully applied. As previously stated, reliance can not be placed on one method alone, and the florist must adopt every measure which he can fit into his cultural program.

CONTROL MEASURES FOR STRAWBERRY ROOTWORM AND WHEN THEY SHOULD BE FOLLOWED.



In drying period use hydrocyanic-acid gas fumigation

Scrape surface soil same day plants are cut back

Spray plants with arsenical same day they are cut back

Use kerosene nicotine oleate to film surfaces of flooded beds

Dust foliage with lead arsenate or calcium arsenate and sulphur

Apply tobacco dust and wood ashes on the soil surfaces

Keep beds clean throughout the year and destroy any beetles which may be found on the plants at any time

The following program combining both cultural and control methods is recommended:

Keep the beds free from dead leaves, weeds, and other trash at all times.

After each syringing, beginning about February 15, dust the plants with a dry mixture consisting of 15 parts of lead arsenate or calcium arsenate and 85 parts of sulphur. Continue this treatment until the plants are cut back.

Keep the bed surface covered with tobacco dust from the middle of February until the drying period and apply wood ashes about once a month as recommended.

During the drying period fumigate three or more times with hydrocyanic-acid gas, the last fumigation to be given the night before the plants are cut back.

Follow the workers who are cutting away the tops with another group to scrape the soil from the surface.

After cleaning out all the tops and after scraping the soil, spray the stalks with lead arsenate or calcium arsenate to protect the bark and "eyes."

Water the beds the day after cutting back and replace the removed soil with new.

As the new growth begins to develop keep it dusted continuously to prevent feeding by beetles.

During September and October keep the plants very thoroughly dusted with arsenicals, because during these months the beetles are emerging and feeding voraciously and the chances of poisoning them at this time are very good.

During these two months apply two or three kerosene nicotine oleate treatments at times when the beds are watered heavily.

PREVENTIVE MEASURES.

The grower who wishes to keep the strawberry rootworm out of his greenhouses will find it necessary to employ several precautionary measures. It is best to obtain soil from fields where there have been no strawberry plants, and this soil should be composted for several months before it is placed in the beds, or else it should be sterilized before using, in order to destroy any of the forms which may be present. Young plants while being propagated are not ordinarily infested, but they should be grown in separate houses free from these insects, and under no conditions is it advisable to keep the young stock in proximity to any infested beds or houses, because of the danger of becoming contaminated. The grower who buys his plants should assure himself that the propagator has used every care to keep the young stock protected from possible infestation.

Florists should keep their greenhouses as clean as possible, removing dead leaves and other débris from the beds, keeping the walks swept, and all nooks and corners free from rubbish. All such material should be removed to a considerable distance from the greenhouse and burned, to preclude the return of any injurious pests which might be thus carried out. The same treatment should be accorded the tops of the bushes which are removed at "cutting back." The importance of these preventive measures is too frequently underestimated by many growers, but scientific evidence and practical results prove that due consideration must be accorded such means of preventing insects from gaining a foothold in the greenhouse.

Plants that have been in beds for three or more years are usually the more heavily infested, and the chances of severe infestation are very much reduced by removing plants and soil at the end of three years at the latest. A rotation should be followed whereby no section of plants will remain in the houses more than three years. For example, if a range of several houses has solid partitions, dividing the place into four separate sections—A, B, C, and D—A and D should be completely cleaned out and replanted one season, B should be handled the next season, and C the third season. At the fourth season the plants in A and D, which would be 3 years old, are replaced, and so on. In this way no plants are retained for more than three years. During the last few years several florists have forced their plants as much as possible for three years rather than try to save them for longer periods of production, claiming that the increase of production by this method more than compensates any extra expense occasioned by the more frequent replanting

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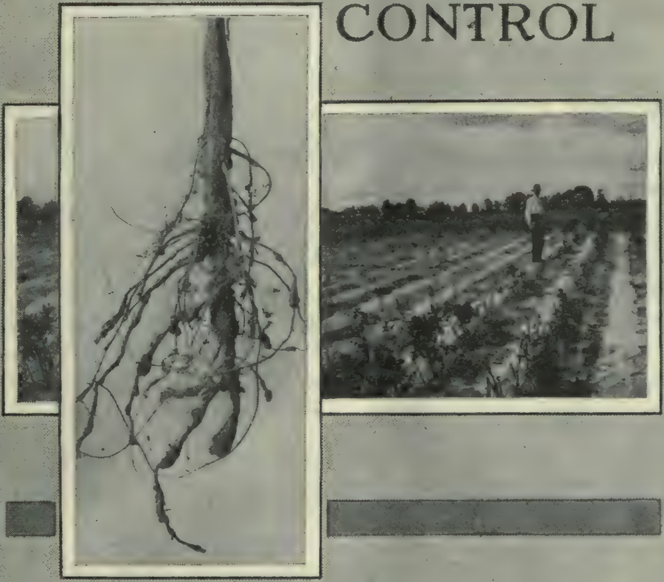
U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1345

ROOT-KNOT

ITS CAUSE AND CONTROL



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ROOT-KNOT is too well known to need an introduction to most growers in the South or to commercial greenhouse men. Its wide range of hosts, the serious losses for which it is responsible, and its constantly widening spread into new localities prove it to be one of the most important of all plant diseases.

Once established in a field, this pest can be eradicated only by starving it to death by planting for two or three years crops not subject to infection, such as the large and small grains, a few of the leguminous crops, and special resistant varieties of others that have been developed by years of selection and breeding.

If a farmer is fortunate enough to have a field free from the disease in a locality where it is prevalent he would do well to stave off the evil day by studiously avoiding this original infestation. This may be accomplished by refusing any tubers, plants, or nursery stock that may be infested and by guarding against its introduction by way of farm implements, compost, manure, tools, or drainage water from diseased fields.

Greenhouse men should make a regular practice of sterilizing soil and seed beds where they have this pest to contend with.

Washington, D. C. Issued October, 1923

ROOT-KNOT: ITS CAUSE AND CONTROL.[1]

By G. H. Godfrey, *Pathologist, Office of Cotton, Truck, and Forage Crop Disease Investigations, Bureau of Plant Industry.*

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INTRODUCTION.

Attention should be directed to the continual spread of a common disease of plants generally known under the names of root-knot, root-gall, and big-root. It occurs as an out-of-doors pest in all except the most northern States, but it is most abundant in the more or less sandy land of the Atlantic and Gulf Coastal Plain regions, all the way from Maryland to eastern Texas, and in the lighter irrigated soils of the Southwest. Here and there it occurs to a serious extent in other parts of the South and West where soil conditions are unusually favorable, and even sometimes in the heavier soils where these are mixed with an abundance of organic matter and used year after year for susceptible crops. It is everywhere prevalent in greenhouses.

Root-knot is the cause of serious damage to many crops. The extent of this damage is difficult to estimate, since it is both direct and indirect and in many cases is overlooked entirely. The direct damage is that caused to the growing crops. The indirect damage results from the fact that the presence of the disease makes it impracticable to grow certain crops which are particularly susceptible to injury.

Careful estimates made on the basis of actual surveys through typical agricultural counties in the Southeast have shown the direct losses due to reduced yield to be enormous. The losses in some cases ran as high as 80 per cent. The loss for cotton in all sandy lands in a single county in South Carolina was estimated at 4.4 per cent. For Georgia the cotton root-knot loss in 1917 was estimated at 4.1 per cent of the crop. Based on these figures, the annual losses in cotton-growing areas known to be infested with root-knot in the entire South were estimated to be approximately 200,000 bales of cotton and 100,000 tons of seed. Careful surveys through certain trucking districts of the South showed losses to be even greater in the aggregate for truck crops. In one county in Florida, for example, losses in snap beans were estimated to be 20 per cent; in cabbage, 1 per cent; in celery, 14 per cent; in eggplant, 21 per cent; in potatoes, 12 per cent; in lettuce, 8 per cent; in peas, 25 per cent; in tomatoes, 13 per cent. Based on prices that were in effect at that time, losses in these and other truck crops not listed amounted to approximately $150,000. Similar figures were obtained from other sections in the Southeast.

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[1] This is a revision and extension of Farmers' Bulletin 648, "The Control of Root-Knot," by Ernst A. Bessey and L. P. Byars, issued April 1, 1915.

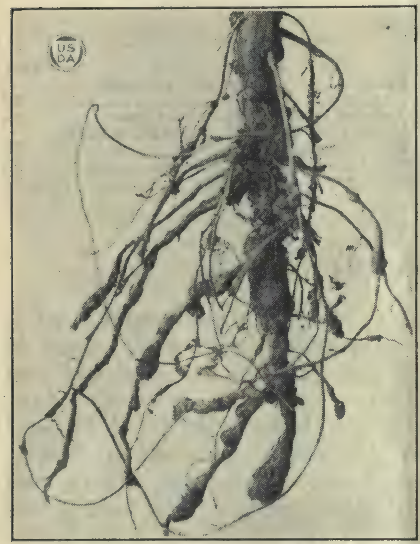

Fig. 1.—Root-knot of the cowpea, showing enlargements caused by the root-knot nematode. All varieties of cowpeas except the four listed in this bulletin are very susceptible to root-knot and should not be used in rotations just preceding cotton or other susceptible crops or as green-manure crops in peach orchards. The four varieties mentioned or other resistant crops should be used instead.

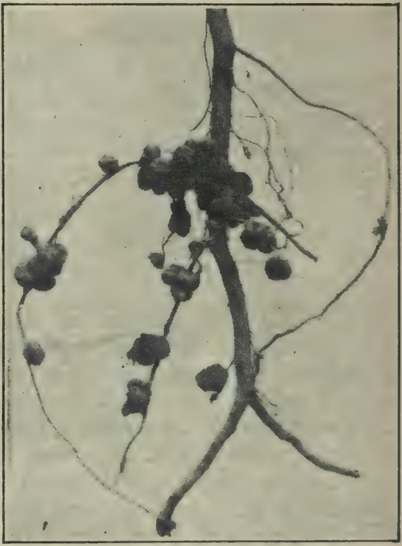

Fig. 2.—Spherical nodules on cowpea roots produced by beneficial nitrogen-fixing bacteria. These enlargements should not be confused with the injurious root galls shown in Figure 1 that are caused by the nematode.

The Southwest also suffers enormous losses. The disease is coming to be a limiting factor in melon production in some parts of southern California. Likewise truck-crop growing in general and potato growing in particular in some of the delta regions of California are menaced. Some nurseries are meeting with heavy losses, owing to the restriction that is placed on the sale of any kind of stock that is infested with the root-knot organism. Figs, grapes, peaches, and walnuts are among the crops sustaining losses in this connection.

APPEARANCE OF PLANTS ATTACKED BY ROOT-KNOT.

As a rule, root-knot produces no malformations or enlargements on the parts of the plant above ground and consequently is frequently overlooked. However, plants badly infested are dwarfed, wilt readily in hot, dry weather, and are usually a paler green than healthy ones. Where the attack is most severe, plants may be entirely killed. In the case of a mild attack, only a small amount of dwarfing, together with a reduction in yield below the normal, is noticeable. Sometimes even the dwarfing is absent, and the reduction of yield is not noticed. Since the disease is widely prevalent in some districts, the reduced yield is supposed by the growers to be a normal one.

On examining the roots of an infested plant the presence of the disease is usually very easily detected. Depending upon the severity of the attack, the fine feeding roots, as well as some or all other roots, will be found to be greatly enlarged at various points. These enlargements may be scattered or they may be so close together that the whole root system is abnormally thickened. Plants affected in this way are frequently said to have clubroot, although the true clubroot is a disease due to an entirely different cause and is confined to plants of the mustard family. Root-knot enlargements in legumes, such as the cowpea and clover, are sometimes confused with the beneficial nodules caused by the nitrogen-fixing bacteria which live in the roots of these plants. Nodules produced by the nitrogen-fixing bacteria are spherical or lobed, small or medium sized, and attached to the sides of the rootlets, from which they may be easily detached. The root-knot parasites, on the contrary, cause swellings in the roots themselves, which can not be broken off readily. They vary greatly in size, from small

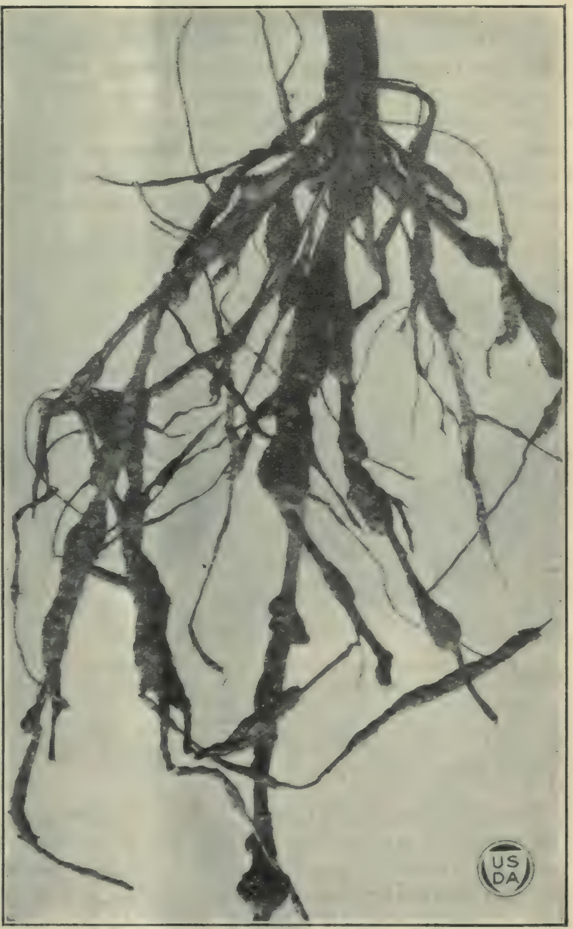

FIG. 3.—Root-knot of cotton. The root-knot parasite may occur in such small numbers as not to be very serious in itself, yet the injuries to the roots caused by it furnish a vulnerable point of attack for the wilt fungus; hence, root-knot in combination with the fungus disease greatly reduces the yield.

swellings in the fine hair roots to great knobs an inch or two in diameter. The pronounced difference in appearance between the injurious root knots and the beneficial root nodules can be seen by comparing Figures 1 and 2, showing cowpea roots, and by studying the various root-knot illustrations, Figures 3 and 10 to 21.

The galls on roots diseased with root-knot, as shown in Figures 1 and 3, interfere with the transfer of water from the fine feeding roots to the stems and leaves, with the result that in rather dry weather on a hot day the plants may wilt through failure to secure the proper quantity of water, even though the soil may be quite moist. Furthermore, the diseased tissues are quite watery and more easily permit the entrance of fungi or bacteria which cause decay, so that the death of the plant may be due immediately to the nematodes themselves or to other parasites that gain entrance to the plant through the injured tissues. A good example of this is often seen in the case of cotton, on which the root-knot parasite alone may be present in such small numbers as not to be particularly harmful beyond reducing the yield somewhat. Yet the injuries to the roots due to this parasite make it possible for the fungus that causes the wilt (black-root) of cotton to gain entrance to the roots much more readily than if the root-knot parasite were absent. Thus, root-knot in combination with this fungous disease greatly reduces the crop.

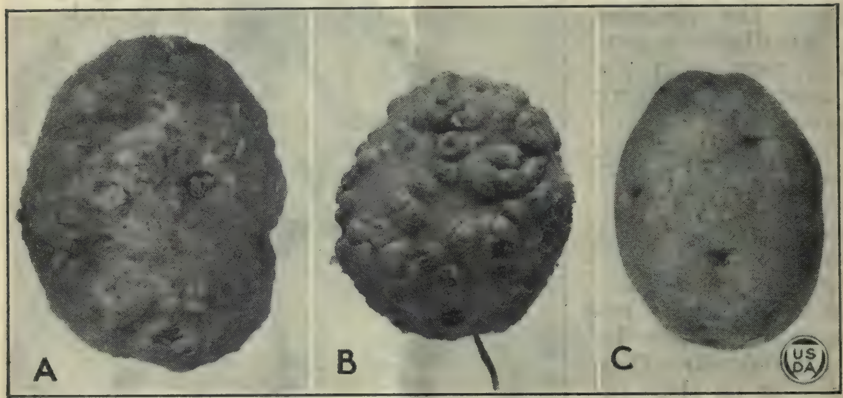

FIG. 4.—Two potatoes, *A* and *B*, badly infested with the root-knot nematode, and one, *C*, free from infestation. The roughened, warty, and discolored surface of the infested tubers are the external signs which indicate the presence of the parasite in the interior. Such diseased tubers are unfit for table use and should never be used for seed purposes. Slightly infested tubers may not show the external symptoms. They are just as capable of starting the disease in a new field, however, and their use as seed should be avoided.

It has been repeatedly demonstrated that it is not profitable to attempt to grow even wilt-resistant varieties of cotton on land infested with root-knot without first rotating with immune crops to reduce the number of nematodes.

It is not always the roots that bear the most conspicuous and harmful effects of root-knot. In certain tuberous plants, like the Irish potato, the swellings on the rootlets may be small, while the tubers when thoroughly infested with the disease are much roughened, discolored, and warty on their surfaces, as shown in Figure 4. By cutting open these potatoes a layer of discolored tissue, which contains the parasites in large numbers, is usually found just beneath the skin. (Fig. 5.) Such tubers are not only undesirable for table use, but are also wholly unfitted for seed purposes, since they carry the cause of the disease and spread it into uninfested districts.

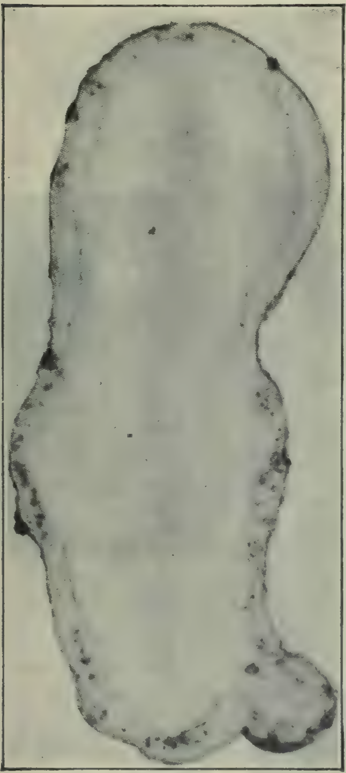

FIG. 5.—Half section of a potato invaded by the eelworm. Just beneath the surface of the tuber is a ring of discolored tissue which contains large numbers of these worms. Planting such tubers spreads the disease rapidly. (After W. A. Orton.)

CAUSE OF ROOT-KNOT.

Root-knot is caused by a minute animal, *Heterodera radicicola.* In the earlier stages of its development this animal is wormlike, and for this reason has been called an eelworm. On account of its production of galls, it may be called the gallworm. It belongs to the group of animals more correctly known as nematodes, many of which are injurious to plants, while numerous others attack animals. The particular species under consideration is found widespread over most of the temperate and tropical parts of the world where the conditions are favorable for its development. Its life history[2] is briefly as follows: Hatching from an egg which is usually less than one two-hundred-and-fiftieth of an inch in length, it is a small, wormlike creature between three and five times as long as the egg; that is, about one-eightieth to one-fiftieth of an inch in length. The diameter of the body is about one-thirtieth of the length. On account of their minuteness, these nematode larvæ are invisible to the unaided eye. They move through the soil with considerable activity, and on finding a root of a susceptible plant, preferably a young feeding root, bore their way into it, usually near its tip. Once inside, the young nematode ceases its active movements, begins to enlarge, and by means of a hollow, spearlike organ within its mouth absorbs its nourishment from the root. A greatly magnified egg is shown

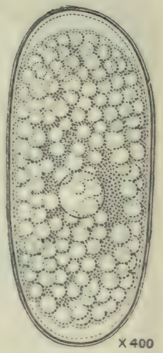

FIG. 6.—A newly deposited egg of the root-knot nematode, magnified 400 times. These eggs are produced in large numbers, some females laying as many as 500. Because of their tough covering, the eggs are resistant to most chemical treatments and to adverse soil conditions. (After N. A. Cobb.)

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[2] Additional information concerning the life history of this parasite, with a list of susceptible plants and details of experiments in controlling the nematode in the southeastern United States, may be found in Bulletin 217 of the Bureau of Plant Industry, Root-Knot and Its Control, by Ernst A. Bessey, issued November 21, 1911.

in Figure 6, and in Figure 7 both eggs and larvæ magnified about 30 times may be seen.

The presence of the nematode in the root irritates the tissues in such a way that the root enlarges, forming a swelling that may be two or three times as thick as the diameter of the root above or below. If many nematodes are present in the root the swellings may become very large, especially as the root increases in age. The female nematode within the root increases in thickness more rapidly than it does in length, so that eventually it is almost pear shaped and large enough to be visible to the naked eye, becoming from one-fortieth to one-twenty-fifth of an inch in diameter. When a root badly infested with these nematodes is broken open at this stage, the mature females, as shown in Figure 8, can frequently be observed as minute, pearly white, rounded bodies from one-fourth to one-half the diameter of the head of a common pin. Figure 9 shows several of them in a small bit of infested tissue. It requires about four weeks for the female to reach full development and begin laying eggs. The female is capable of laying more than 500 eggs, each of which may hatch into a wormlike larva, as mentioned above.

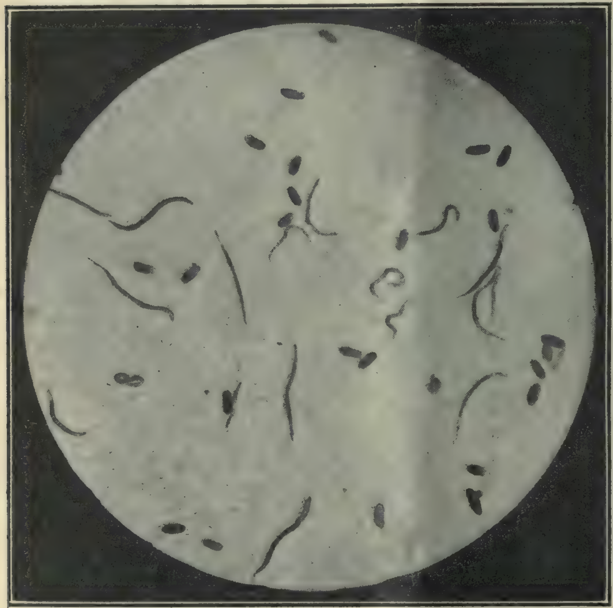

FIG. 7.—Illustration made from a photomicrograph of the eggs of the eelworm and the young worms just hatched, taken from a potato. It is in this worm stage that the parasite moves through the soil and enters the roots or tubers of plants. (After F. B. Headley.)

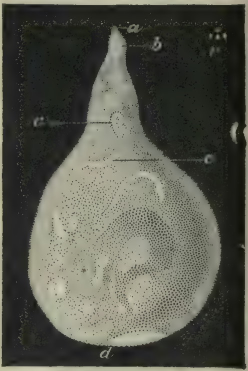

FIG. 8.—A female of the eelworm (*Heterodera radicicola*) magnified 85 diameters: *a*, Mouth; *b*, spherical sucking bulb; *c*, *c*, ovaries, as seen through the body wall; *d*, anus; *e*, small white spots showing approximately the natural size of these worms. During the egg-laying period they are usually a glistening white and can be readily seen with the unaided eye by carefully breaking open an infested gall. (After N. A. Cobb.)

The males are rarely seen except when searched for at just the right period. Their development up to a certain stage is like that of the female; that is, the larva enters the root in the same way and enlarges within it, but after becoming much elongated and shedding a skin it bores its way out of the root into the soil again. It is then a wormlike animal one-sixteenth to one-twentieth of an inch in length, but not over one-fortieth as thick as it is long. It is practically invisible to the naked eye.

In the warmer climates, such as southern Florida, southern Texas, and parts of California, it is possible for the nematodes to pass through as many as 10 to 12 generations in a year, but in the cooler climates the number is less. The number of generations is governed by the temperature, since the nematodes do not develop except when the soil is warm. Thus, in northern Florida, December, January, and February are months in which little nematode injury occurs. In South Carolina the comparatively quiescent period lasts from the middle of October to the middle of April, and in New York, Michigan, and Colorado the active period is probably not much longer than the three warmest summer months.

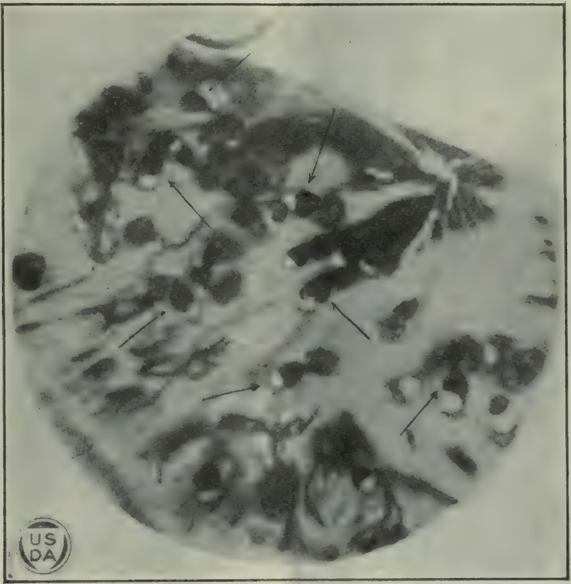

FIG. 9.—Highly magnified section of a severely infested sugar-beet root, showing the numerous adult female nematodes embedded within the tissue. This illustration represents an area about one-fourth inch in diameter.

PLANTS ATTACKED BY ROOT-KNOT.

The root-knot nematode attacks a large number of plants of widely different types. The kinds of plants on which it is known to occur number over 500, and doubtless future observations will greatly extend this list. Among those subject to attack are many in which the nematodes inflict no visible injury upon the plants, being found only in a few of the smaller roots in such small numbers that they are negligible, as far as the plant is concerned. Many of the common weeds belong to the class of plants which harbor the nematodes and at the same time show few of the symptoms. However, such plants are dangerous from the farmer's standpoint, since they help to keep the soil stocked with the nematodes. When it is considered that one female may produce more than 500 eggs, it is evident that not many individuals are required to keep the ground thoroughly infested. The young nematodes are able to exist in the soil for more than a year, working their way through it during the warm weather in search of roots into which they may enter. For this reason it is important to keep the ground free from the plants upon which the nematodes feed.

Besides the plants that are only slightly infested some are found in which the nematode galls are very abundant on the roots, yet with no apparent damage noticeable in the crop. Such plants, perhaps, make up the majority of the susceptible ones. There is a third class, however, in which the nematode injury is very severe and easily noticeable. Such plants make poor growth, are stunted, give reduced crops, or are killed prematurely, while the roots are found to be masses of swollen structures scarcely recognizable as roots. In badly infested areas the sugar beet, squash, tomato, lettuce, muskmelon, and celery, as illustrated in Figures 10 to 15, present all the root symptoms described for this third class of plants. Somewhat less conspicuously, the effect of the parasite upon woody plants, such as the grape, willow, and fig, is shown in Figures 16, 17, and 18. In Figures 19, 20, and 21 the results of gallworm infection of the primrose, chrysanthemum, and carnation are clearly shown.

A large number of the commonly cultivated plants are more or less subject to the disease. The classified list which follows includes the more important, highly susceptible plants. These should never be grown on infested fields or transplanted from any field that may possibly contain the parasite.

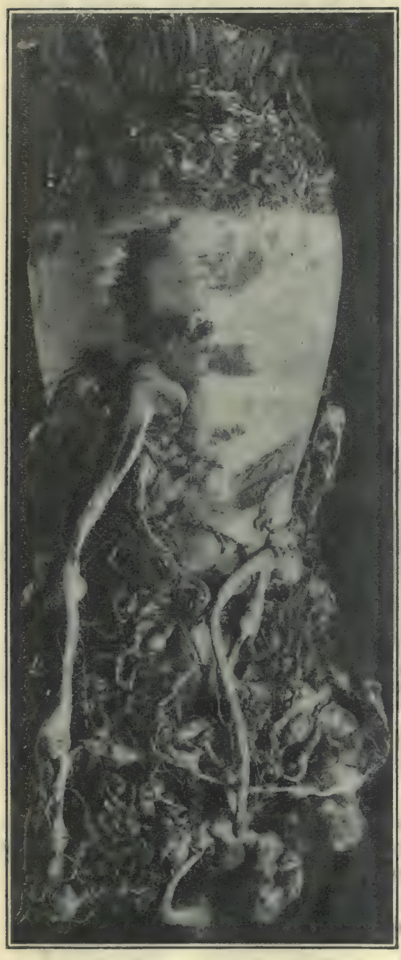

FIG. 10.—A sugar beet affected with root-knot. In certain sections of the Southwest the growing of sugar beets has been prevented by this disease.

PLANTS SUBJECT TO ROOT-KNOT.

- Field crops:
  - Alfalfa.
  - Clover.
  - Cotton.
  - Cowpea (except Iron, Brabham, Monetta and Victor).
  - Field pea.
  - Flax.
  - Pumpkin.
  - Soy bean (except Laredo).
  - Sugar beet.
  - Sugar cane.
  - Sweet potato.
  - Tobacco.
  - Vetch.
- Ornamental and drug plants:
  - Begonia.
  - Cineraria.
  - Clematis.
  - Coleus.
- Ornamental and drug plants—Continued.
  - Dahlia.
  - Hollyhock.
  - Ginseng.
  - Goldenseal.
  - Peony.
  - Rose.
  - Sweet pea.
  - Violet.
- Truck crops:
  - Asparagus.
  - Bean.
  - Beet.
  - Cantaloupe.
  - Carrot.
  - Celery.
  - Cucumber.
  - Dasheen.
  - Eggplant.
  - Garden beet.
  - Garden pea.
  - Lettuce.
- Truck crops—Continued.
  - Muskmelon.
  - Okra.
  - Onion.
  - Pepper.
  - Potato.
  - Salsify.
  - Spinach.
  - Strawberry.
  - Tomato.
  - Watermelon.
- Woody plants:
  - Almond.
  - Catalpa.
  - Cherry.
  - European elm.
  - Fig.
  - Mulberry.
  - Old World grapevine.
  - Peach.
  - Pecan.
  - Persian walnut.
  - Weeping willow.

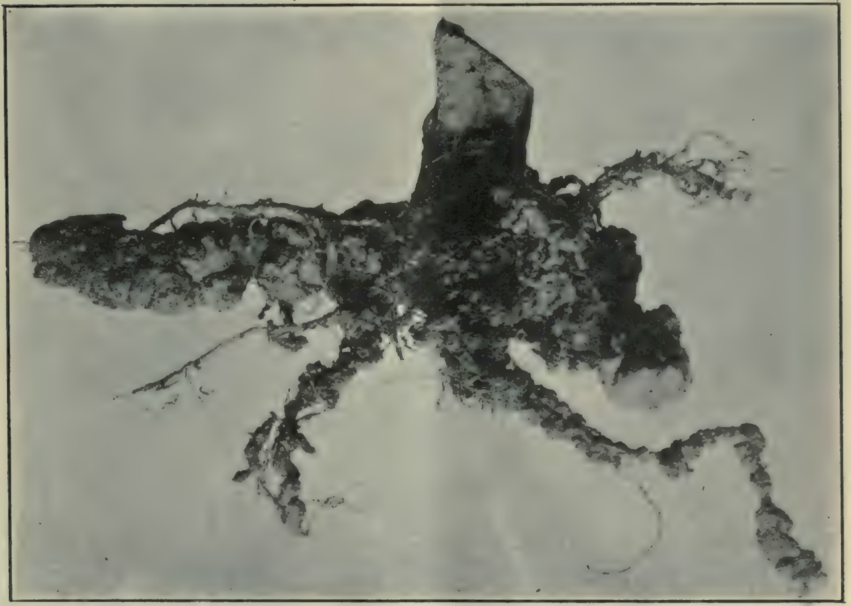

FIG. 11.—Squash roots affected with root-knot. The entire root system has become infested with the parasite; hence, the proper amount of food material does not reach the parts of the plant above ground.

Besides the above-listed plants, most of the common weeds are attacked by the nematodes, some of them very severely. Such weeds are a constant source of danger to the farmer, as they help to increase the number of nematodes in the soil. An abundance of weeds is a sign of poor agricultural practice anywhere, but weeds become doubly dangerous where they not only do harm by crowding out other plants and using up food intended for them, but also multiply a pest which may later destroy the planted crops.

PLANTS NOT ATTACKED.

Fortunately, many plants of economic importance are known to be free from the attacks of root-knot. As will be shown later, advantage is taken of this fact in controlling the disease. The following list includes the more important cultivated plants which, so far as known, are seldom or only slightly affected by the nematodes and may be used in crop rotations with the expectation of greatly reducing the number of eelworms.

PLANTS IMMUNE OR ONLY SLIGHTLY SUSCEPTIBLE TO ROOT-KNOT.

Barley.
Beggarweed.
Broom-corn millet.
Chufas.
Corn.
Cowpea, Brabham, Iron, Monetta, and Victor varieties.
Grasses (nearly all).
Kafir.
Milo.
Natal grass.
Peanut.
Pearl millet.
Redtop.
Rye.
Sorghum.
Soy bean, Laredo.
Timothy.
Velvet bean.
Wheat.
Winter oats.

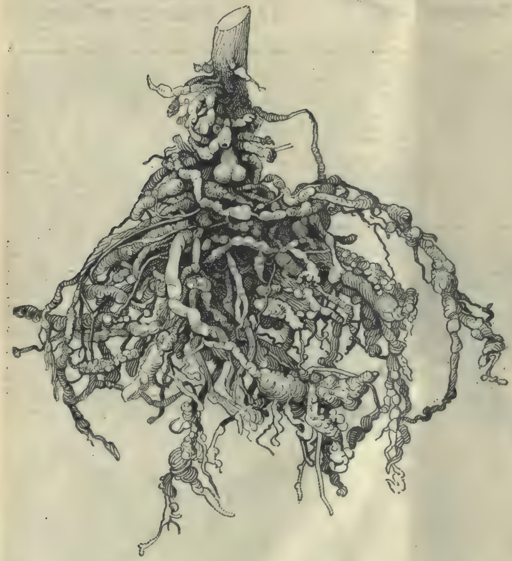

FIG. 12.—Roots of a tomato plant completely invaded by nematodes. Most varieties of tomatoes are severely attacked by the parasite. (After George F. Atkinson.)

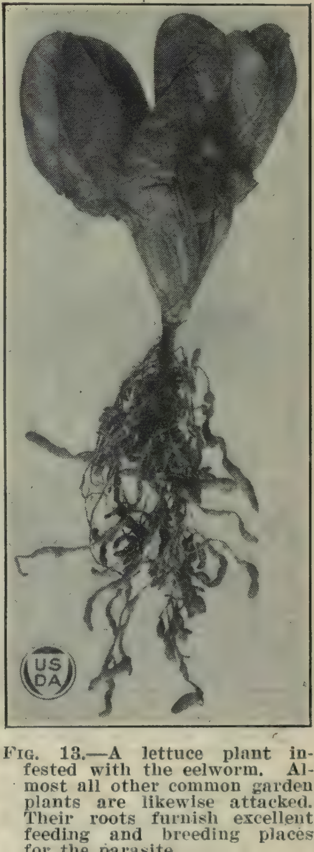

FIG. 13.—A lettuce plant infested with the eelworm. Almost all other common garden plants are likewise attacked. Their roots furnish excellent feeding and breeding places for the parasite.

CONDITIONS FAVORING ROOT-KNOT.

Root-knot is seldom found in heavy soils, apparently because it is difficult or almost impossible for the young nematodes to make their way from one root to another through such soils. Occasionally a garden in such soil which has been made lighter by repeated applications of manure or other humus and frequent cultivation and into which the pest has been introduced may gradually become badly infested. This accounts for some of the reports of the disease in localities not ordinarily considered subject to it because of generally unfavorable soil conditions. Most root-knot occurs in light soils, especially those of a very sandy nature. There is therefore much more risk of infestation in growing susceptible plants on light sandy soil than on those which are heavy or stiff. Where the land is water-soaked for a considerable period of the year these nematodes are not abundant or do not occur at all, nor are they found, on the other hand, in land that is exceedingly dry. Warm soil is necessary to their development. Below 55° F. the nematodes, even if present, are relatively inactive, and very little infection occurs. Above that point their activity is great up to the maximum temperature for the growth of any of their host plants. Since 55° F. is none too low for the growing of many crops, this knowledge can sometimes be applied successfully in growing susceptible crops on infested ground. Thus, celery and lettuce can be grown during the fall, winter, and early spring on infested land in some parts of Florida. The same land planted to tomatoes, eggplant, or okra later in the season when the soil is warm produces plants greatly damaged by root-knot. Likewise in a greenhouse lettuce can be grown in soil that has shown itself to be infested with nematodes provided the soil temperature is not permitted to go above 55° F.

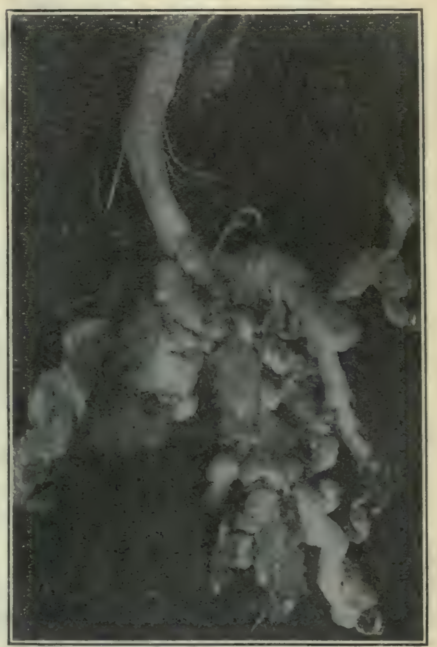

FIG. 14.—Roots of a muskmelon plant, showing enlargements due to the eelworm. Other truck and field crops are similarly attacked and should never be planted two successive years on infested land.

Severe freezing of the ground kills out most of the nematodes near the surface. The infestation may survive even the most severe winters, however, provided the soil is the proper type to permit the nematodes to reach a considerable depth. Carried thither by their own activities and by movements of the soil water, they live over in an inactive condition. Upon the return of a favorable environment the following season, those that have survived resume their activity and infest such susceptible plants as may be available. Thus, they are found to an injurious extent at times in such Northern States as Michigan, Nebraska, Colorado, Utah, and Idaho. Here, however, only one or two generations develop during the summer, owing to the shortness of the season, and they never become exceedingly abundant unless other conditions are unusually favorable. A long summer permits the development of several generations, thereby very greatly increasing the nematode content of the soil.

Root-knot nematodes occur in greatest abundance in the light sandy soils of the South and Southwest, where they have the proper texture of soil combined with a desirable quantity of moisture, freedom from winter freezing, and a long, warm summer. The same combination of favorable conditions accounts for their very wide occurrence in greenhouses.

METHODS BY WHICH THE PARASITE IS SPREAD.

The larvæ of the nematode are capable of moving through the soil only very slowly, perhaps not more than a few feet each year. Yet this movement suffices to permit many of them to descend to a sufficient depth in the soil to escape drought and frost. It is not primarily by its own efforts, however, that the parasite is spread. It may be transported from field to field in a given district along with the soil that clings to agricultural implements, to the feet of domestic animals or man, or to transplanted plants. Too much care can not be exercised to prevent the distribution of infested plants or soil on plants to areas which are free from the pest. Garbage, manure, waste matter of any kind containing parts of diseased tubers or roots may spread the parasite and should never be placed on uninfested land. The pest is also frequently carried to other fields by means of surface water resulting from heavy rains. Irrigation water undoubtedly plays a very large part in the distribution of the disease in the semiarid districts of the West and Southwest. Again, it is probable that the organisms are carried from field to field by the dust storms which occur in some infested localities.

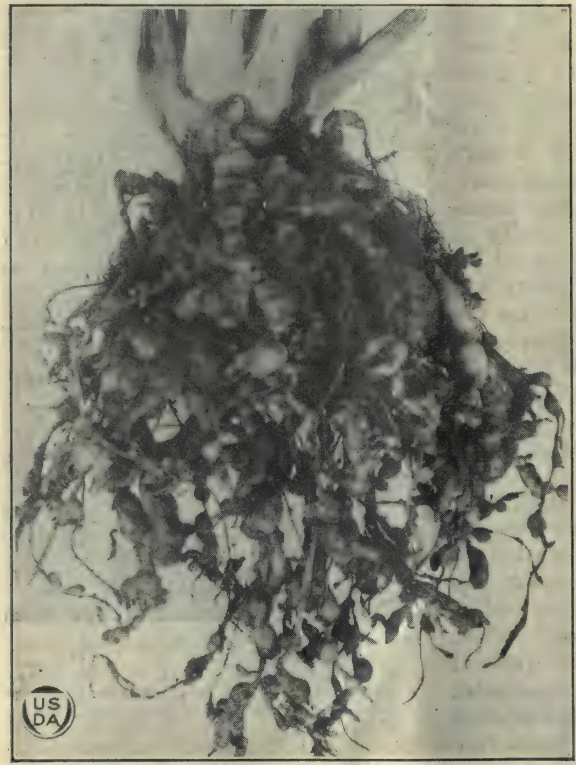
FIG. 15.—Root system of celery thoroughly infested with the root-knot nematode. To control this parasite at least a 2-year rotation with resistant crops is necessary.

The most common method of transporting the disease from one locality to another is through shipments of nursery stock, tubers, bulbs, and seedlings. Numerous observations, particularly in the Southwest, have shown that peaches, figs, and Old World grapevines are the means by which new areas become infested. Florists and nurserymen have unwittingly been the cause of the disastrous spread of the parasite. The appearance of root-knot in new localities has repeatedly been traced directly to nurserymen who were not informed as to the nature of the disease. This suggests that no nursery stock should be accepted until it has been found free from nematodes, and if suspected of having come from infested districts it should be planted on a separate part of the farm until upon examination later it is found to be free from the trouble.

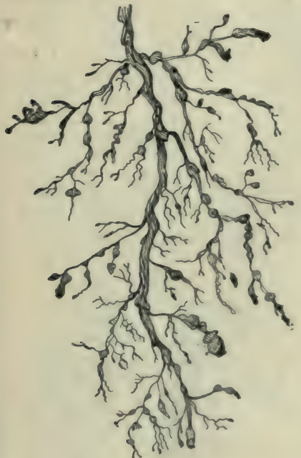

Fig. 16.—Root system of the Black Hamburg grape, showing small swellings due to the eelworm. The parasite causes much damage every year to many crops which the grower supposes are normal. (After J. C. Neal.)

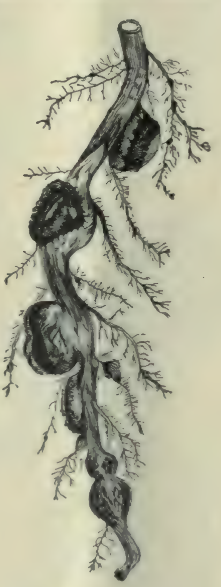

Fig. 17.—Roots of a weeping willow diseased with root-knot. Many ornamental plants are subject to this disease and should not be planted in soil known to be infested with the eelworm. (After J. C. Neal.)

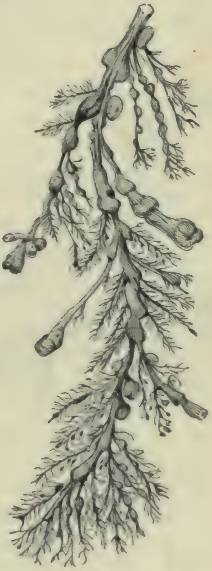

Fig. 18.—Roots of the fig, showing swellings caused by the root-knot nematode. Most varieties of the fig are especially susceptible to the attacks of this parasite, which thrives in moist, sandy soils suitable for fig growing. (After J. C. Neal.)

In certain irrigated districts of California and Nevada seed potatoes (see figs. 4 and 5) have been chiefly instrumental in introducing and spreading the nematode. In attempting to control this disease it is absolutely essential that only uninfested tubers be planted. To use tubers showing no superficial evidences of the disease is not enough, but clean and healthy seed should be selected from fields where a critical inspection shows that root-knot has not been present. It naturally follows that potatoes which are to be used for seed purposes should be obtained from uninfested localities, preferably from States along the northern border of the United States from Minnesota to Maine, where the extreme temperatures practically prevent the occurrence of the nematode as an out-of-door pest.

In the South and East, cabbage, sweet potato, tobacco, and tomato plants (fig. 22), as well as various classes of nursery stock, such as the fig, peach, and mulberry, are means through which the parasite is known to be most frequently transferred into new localities. The prevalence of the pest in ginseng plantations is undoubtedly due to the transplanting of rooted seedlings from infested soil and to the use of seed which were packed in damp infested dirt.

METHODS OF CONTROLLING ROOT-KNOT.

Root-knot control is not as simple a matter as the control of some other plant diseases, inasmuch as the affected parts of the plants are entirely underground and therefore difficult to reach with protective materials. Control must of necessity consist not in the cure of plants that are already affected, which is practically impossible, but rather in the eradication of the pest from the soil. This may be accomplished directly by sterilization of the soil or indirectly by crop rotations designed to starve out the organism by cutting off the supply of food. A further control method consists of the development of resistant varieties.

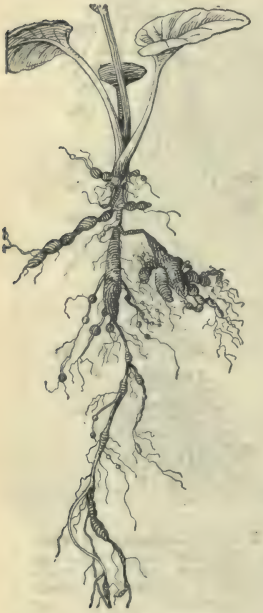

Fig. 19.—Primrose roots badly infested with the eelworm. Greenhouse soils kept at a mild, even temperature furnish excellent conditions for the growth and rapid increase of this parasite. (Drawing furnished by N. A. Cobb.)

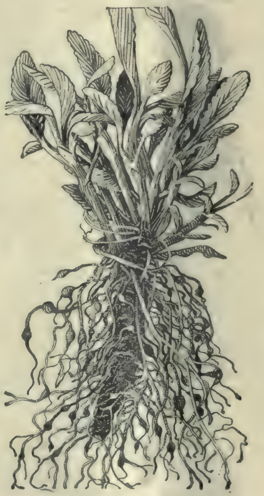

Fig. 20.—Chrysanthemum, the roots of which are infested with the eelworm. Plants severely attacked by this parasite are often dwarfed; they grow slowly and serve as breeding places for the nematode. (Drawing furnished by N. A. Cobb.)

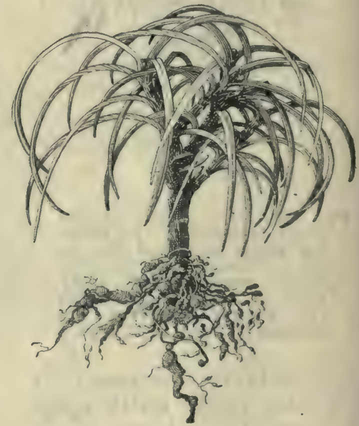

Fig. 21.—Carnation plant, the roots of which are much distorted and swollen as a result of eelworm infection. Many greenhouse plants are similarly attacked when grown in soil which has not been sterilized. (Drawing furnished by N. A. Cobb.)

GREENHOUSES AND SEED BEDS.

Soil sterilization by one means or another is most often resorted to in greenhouses and seed beds. Many chemicals have been experimented with for this purpose, some with promising results, but their complete practicability has not yet been demonstrated. The application of heat has thus far been the most practicable method of killing the organism which causes root-knot.

STERILIZE WITH STEAM OR HOT WATER.

A very common method of soil sterilization by heat uses perforated steam pipes. This consists of heating the soil by passing steam into perforated 1½-inch pipes laid lengthwise in the benches from 1 foot to 1½ feet apart and at a depth of 1 foot below the surface of the soil. Eighth-inch holes are made on the under side of the pipes at intervals of about 6 inches. The soil can be thoroughly heated in the course of an hour or more, depending on the steam pressure, until all nematodes, as well as most of the bacteria and other fungi which cause plant diseases, are killed. It has been found desirable to cover the soil with a canvas or a layer of straw held on by boards laid closely together, in order that the steam may not merely blow through the soil at certain points but may rather be distributed evenly throughout the bed. The higher the steam pressure, the more quickly the proper temperature is attained, with the further advantage that at high pressures the soils do not become so water-logged as they do if low-pressure steam is used. A convenient method often employed to determine whether the steaming has continued long enough is to bury potatoes at various points in the surface of the beds. When these are found to be cooked, one need have no fear that any nematodes will remain alive. Indeed, they probably perish long before the potatoes heat through.

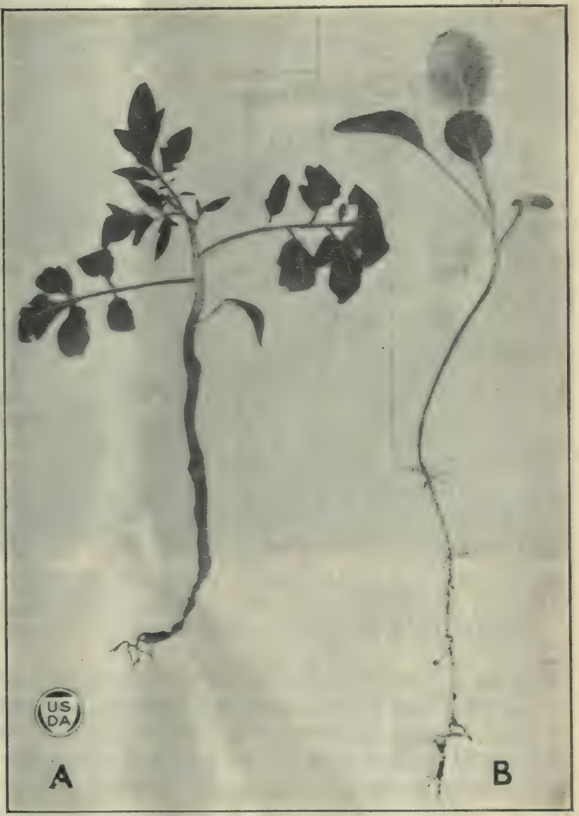

FIG. 22.—Tomato (*A*) and cauliflower (*B*) seedlings somewhat severely affected with root-knot. If cabbage, cauliflower, celery, lettuce, tobacco, tomato, or any other seedlings when taken from the seed beds or flats show even very slight infestation, they should be discarded; otherwise, the soil where they are planted is sure to become infested. Every knot on a root contains at least one female nematode, which may contain as many as 500 eggs.

Another way to steam-sterilize the soil, perhaps in even more wide use than that just described, is known as the " inverted-pan method." This has been described at length in Farmers' Bulletin 996, Steam Sterilization of Seed Beds for Tobacco and Other Crops, to which the reader is referred for detailed information. It consists essentially of an iron or wooden pan of convenient size for covering the entire width and considerable of the length of the beds, 6 by 12 feet and 4 inches deep being a common size. The pan is inverted over the bed and the edges thrust into the soil. To insure still further against the wastage of steam, soil is banked up around the edges of the pan. Then steam under pressure is turned into the pan through a special inlet. The length of treatment required must be learned by experience, as it varies with the type of soil and with the steam pressure available from 30 minutes to 2 hours. The same test may be applied as that described previously, namely, inserting a potato to a depth of several inches into the soil and leaving the pressure on until it is completely cooked. Considerable economy of heat can be secured by immediately covering a newly sterilized section of a bed with heavy canvas. This not only conserves the heat for a longer period, but makes it actually penetrate deeper into the soil. Figure 23 illustrates a complete steam-sterilization outfit used in tobacco seed beds.

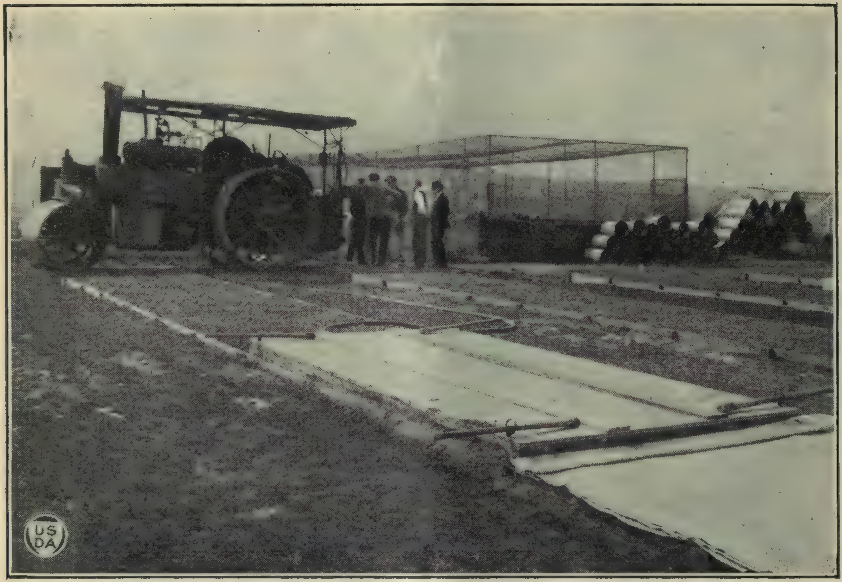

FIG. 23.—A complete outfit for the sterilization of tobacco seed beds by the steam-pan method. A traction engine or any other type of boiler, stationary or movable, may be used as a source of steam. The inverted-pan treatment is often followed immediately by the application of several thicknesses of canvas, to prolong the treatment.

In case regular treatments by either of these methods do not appear to keep the pest in check, it is probable that it is because of one of two reasons: (1) It may be reintroduced in some manner each season, such as by way of the manure, compost, or new soil, by implements used previously in infested soil, by planting infested plants, or even by the water itself. The remedy in this case is to guard against every possibility of reintroducing the pest. (2) Certain parts of the soil may have escaped treatment. For example, it is possible that large numbers of the organisms may have worked their way under the walks in their search for food, thereby escaping the treatment, and they may later work their way out again and reinfest the treated soil. This condition may be guarded against by such special treatment as the occasion may justify. Loosening the soil under the edges of the walks at the time of sterilization and giving a special treatment by means of a buried perforated steam pipe should give good results. Again, extending the edges of concrete walks to the very bottoms of the beds may be a suitable remedy.

A very convenient method for the use of steam where it is desirable to sterilize in pots and flats is to build a special vault or cabinet of concrete or tightly fitting lumber into which the soil may be rolled on trucks. The door should be so arranged as to close tightly. Steam may then be applied for two or more hours, the length of time varying with the pressure that is available and the tightness of the cabinet.

Still another application of heat as a sterilizing agent is its use in the form of hot water. While not so good as the steam treatments where steam is available, it is nevertheless effective in ridding the soil of the root-knot nematode and may be of considerable value to those unable to secure the use of steam. It may be applied either by immersing the pots in boiling water or by pouring the water directly into the pots, flats, or benches at the rate of about 7 gallons per cubic foot of soil. In this case several days must be allowed for the soil to drain before planting. This method is treated fully in Department Bulletin No. 818, Soil Disinfection with Hot Water to Control the Root-Knot Nematode and Parasitic Soil Fungi, which also contains an account of the experimental work upon which it is based.

All of these soil-sterilization methods and various modifications of them, which are treated more fully in Farmers' Bulletin 1320, The Production of Cucumbers in Greenhouses, are in practical use in the large commercial greenhouses.

Where steaming is impossible, greenhouses may still be freed from nematodes by removing the infested soil, whitewashing the benches with fresh boiling-hot whitewash and refilling them with fresh soil taken from some point where, by the observation of susceptible plants, it has been found that no nematodes are present. Fresh soil that is entirely or nearly free from the nematodes may be secured from low bottom land or any land that is flooded for a considerable period, preferably two to six months each year.

These methods apply, of course, only to beds which contain no living plants. It is impossible to formulate a rule of procedure that will be satisfactory in all cases in freeing beds of living plants from nematodes. If the plants are capable of being transplanted, they may be removed from the soil, washed, and all diseased roots cut off, cutting back the tops to correspond, and then transplanted to fresh soil. Before replanting it is well to soak the roots for half an hour or more in a solution of 1 part of 40 per cent formaldehyde in 100 parts of water, in order to kill any nematodes that may be present in the dirt adhering to the surface.

ORCHARDS.

PLANT ONLY CLEAN NURSERY STOCK.
USE IMMUNE COVER CROPS.
FERTILIZE AND CULTIVATE THOROUGHLY.

When planning to set out a new orchard, it is highly desirable, where possible, to avoid land that is infested with the root-knot nematode. Presence or absence of infestation can usually be determined by examining the roots of such previous crops as are known to be susceptible (see p. 9), and even of weeds, many of which harbor the pest. Low-lying sandy areas, particularly those receiving the drainage from a hill above, are more likely to be infested than a hillside and are generally to be avoided. If the land is known to be infested it is far better to wait the required number of years to free it from the pest by growing immune crops than to risk ruining the trees by a heavy infestation of root-knot. Any of the resistant crops listed in the section headed "Plants not attacked" are good for this purpose. To plant very susceptible crops, such as melons, cucumbers, tomatoes, or the ordinary varieties of cowpeas, in a field that is later to be occupied by an orchard or other permanent crop is highly undesirable. The nematodes will multiply in great numbers on the susceptible plants and so infest the soil that the permanent crop will be seriously injured.

Where an orchard is free from the disease or nearly so, every effort should be taken to maintain this condition and avoid the necessarily expensive control methods. All nursery stock should be carefully examined and no tree planted that shows any sign of the disease on its roots. Only the resistant legumes listed in this bulletin should be used as summer cover crops. The bush velvet bean is coming to be more and more commonly used for this purpose. It is especially desirable, in that it is practically immune to root-knot and is one of the best soil improvers known.

Where only a few trees in a young orchard are affected (and this is often the case when partially infested nursery stock has been planted on uninfested land), they should be removed and destroyed. The surrounding soil, including an area well beyond that occupied by the infested roots of the removed tree, should then be loosened thoroughly and treated with a solution of formaldehyde (1 part of 40 per cent formaldehyde to 50 parts of water) at the rate of about 3 to 4 gallons per square yard. In this way the further spread of the disease is prevented, and nematode-free trees may be replanted after at least one year's delay with little fear of their becoming infested.

Where a large producing orchard is showing signs of deterioration on account of root-knot infestation the problem is a special one, and no entirely satisfactory treatment has been worked out. Peach growers often combat the disease with good success by "forcing" the trees to grow in spite of the presence of the pest. They cultivate thoroughly and apply an abundance of fertilizer, particularly stable manures and commercial nitrogen-bearing fertilizers rich also in potash, so that the roots are made to grow faster than the nematodes can produce knots. The use of immune legumes as cover crops is particularly recommended in infested orchards. Aside from being a good horticultural practice from the point of view of the addition of humus and nitrogen to the soil, a good crop of immune legumes is beneficial in that it keeps in check the weeds that are hosts to the nematodes. Commercial peach growers of Georgia and adjoining States are handling the situation by these methods and maintaining a high degree of productivity in their orchards. Where these control measures are not consistently followed, however, the renewed vigor results in only a temporary relief, as the new root growth subsequently becomes invaded by the parasite and the plant is reduced to a state of nonproductiveness.

One means of preventing root-knot in peach orchards practiced in certain parts of Florida is that of grafting the peach on the native wild plum. This method has proved successful from the standpoint of the disease, because the wild plum is resistant to root-knot. As a general horticultural practice, however, grafting the peach on the wild plum has not given satisfactory results.

FIELDS NOT USED FOR PERMANENT CROPS.

The most satisfactory method of combating root-knot is that in which the infested fields can be planted to nonsusceptible crops for a period of years. To be sure, nematodes can be starved out entirely in two years or a little more if the ground is kept absolutely free from vegetation of all kinds, but this is impracticable on a large scale and in many regions, because of the consequent erosion of the soil, the leaching out of the food substances, and the money loss due to the nonproductivity of the field for that period. However, by making use for about three years of a rotation in which the plants used are not susceptible to the disease, the cost of controlling the nematodes may be considerably reduced, while the land may be actually enriched. Not only is the nematode subjugated by the proper system of rotation, but the same is true of other plant diseases which increase from year to year when the land is repeatedly planted to one crop. As a general agricultural practice, rotation has everywhere proved a necessity to successful farming.

ROTATE.
STARVE OUT THE NEMATODES
BY GROWING IMMUNE CROPS.

The rotations that have been found to be desirable are those in which a summer leguminous crop, with or without corn, alternates with a winter grain. In making these rotations it is, of course, necessary that the crops grown in the summer be free from the attacks of the root-knot nematode. By using leguminous crops the land is enriched while the process is being carried on, and by selecting the proper crops the rotation can be carried on at a profit. The summer crops which have been found most satisfactory for this purpose are corn, velvet beans, Florida beggarweed, the Laredo soy bean, and cowpeas of the Iron, Brabham, Victor, or Monetta varieties, which are highly resistant. Corn should be planted at the usual time in early spring and followed later by velvet beans or one of the resistant varieties of cowpeas, which are drilled between the corn rows. Corn and cowpeas or bush velvet beans planted in this manner make a very desirable combination, as they permit clean cultivation. Of the legumes, beggarweed has the disadvantages that the seed is expensive and that its growing season is so long that it does not permit seed production except in the extreme Southern States. In certain parts of Florida even the resistant cowpeas are subject to injury by root-knot. While this injury is not severe enough to destroy the plants, it is yet inadvisable to grow even these resistant varieties in such places, since by so doing the nematodes are increased. In other parts of the South the only disadvantage of using cowpeas lies in the difficulty of securing unmixed seeds of the resistant varieties. If seeds of other varieties are present, abundant infestation will result. In such sections the velvet bean is especially valuable because of its practically complete immunity to root-knot. Farmers' Bulletin 962, Velvet Beans, deals with this crop, which has become increasingly important as a forage plant and soil improver throughout the southern part of the United States, some varieties doing well even as far north as Virginia. Corn and velvet beans are frequently grown together, this combination being a particularly good one in so far as root-knot control is concerned. The four legumes mentioned, namely, beggarweed, velvet bean, the resistant soy bean, and the cowpea (resistant sorts), seem to be the best that can be recommended, although the Spanish peanut appears also to have qualities which should fit it for similar use. By referring to the list of immune plants it will be seen that other immune summer crops could be used, such as sorghum, millet, Natal grass, or redtop.

The two most successful winter crops in the South are winter rye and winter oats, although the latter does not seem to be satisfactory on many of the very light, sandy soils. In certain latitudes the grain may be allowed to ripen; then the velvet beans or beggarweed should be sown. This should be harvested in time to permit the ground to be prepared for sowing the winter grain or else pastured for the winter.

In view of the above facts, the following rotations are suggested for fields infested with root-knot: In the fall sow winter rye so early that it can make a good growth before it is necessary to plow the land for the next crop. Turn under the rye as green manure in early spring and plant corn, later placing resistant cowpeas in the drill between the rows. The second fall sow winter grain, preferably oats, which may be allowed to ripen or may be cut for hay while green. Follow this with one of the resistant varieties of cowpeas, which can be sown broadcast, or, better, in 2-foot drills, where they can be cultivated. Harvest the cowpeas as hay, and if a 3-year rotation is desired sow winter grain, allow it to ripen, and again broadcast a resistant cowpea to be cut as hay. Barley or wheat may be substituted for the oats and rye, and (in the second and third years) velvet beans or beggarweed may be used instead of cowpeas. Where the velvet bean is used it is often left on the ground all winter as winter pasture for hogs or cattle.

It is possible to starve out the nematode by the 2-year rotation if it is carried on very carefully. However, it seems better, where possible, to use the 3-year rotation. The completeness with which the nematodes are exterminated by the process here outlined depends largely upon the care with which the work is performed. Thus if weeds or volunteer plants from a previous susceptible crop, such as Irish potatoes, are allowed to be present during the summer, the nematodes may be harbored by these and the extermination will not be complete. If the field is subject to overflow by surface water from adjacent infested land, fresh infestation will be the result and the value of the rotation will be lost. The same result will follow if infested soil is introduced on plows, cultivators, wagon wheels, horses' hoofs, etc. It would be desirable to dig a ditch 2 feet wide and a foot or two deep along those sides of the field that border infested fields which are higher up. Besides preventing overflow, the ditch will make a kind of natural boundary, across which animals or implements should not be allowed to go.

In regions of general infestation, as in many parts of the South, the reinfestation of fields which have been freed of nematodes is very likely to occur. For this reason it is desirable to introduce a two-year or three-year nematode-extermination rotation, such as that outlined above, at least every three or four years. In this way serious infestation is prevented. In such a rotation it is desirable to plant the most susceptible crops immediately after the field has been cleared of nematodes and to follow them by those which are less susceptible until the time comes to apply the extermination rotation again.

Pineapple growing is a rather specialized industry which has the root-knot nematode to combat. A disease known as red wilt is due largely to this organism. This disease and its successful control by crop rotations is treated fully in Farmers' Bulletin 1237, Pineapple Culture in Florida. Ginseng, another very specialized crop, is also subject to root-knot unless special measures are taken to avoid it. Such measures are dealt with in Farmers' Bulletin 736, Ginseng Diseases and Their Control.

HOT-WATER TREATMENT FOR DASHEENS.

Dasheens, like potatoes, are affected by the penetration of the organism directly into the tuber itself. Tubers so infested, even though very slightly, should not ordinarily be used for seed, since they would carry the disease with them. In the case of dasheens, however, a hot-water treatment has been worked out which makes it safe to use slightly infested tubers without danger of spreading the organism.

TREAT SEED DASHEENS
40 MINUTES AT 122° F.

The treatment consists of immersing the tubers for a period of 40 minutes in water kept at a temperature of 122° F. If the temperature of the water falls below this for more than a few moments the nematodes may not be killed, and if it rises above 126° F. the tubers may be injured.

For the best temperature control a rather large volume of hot water is desirable, and an accurate thermometer should be kept suspended in it so that the temperature can be determined instantly at any time during the treatment. The temperature may be regulated by keeping a low fire under the vessel or by adding hotter water when needed and cold water when the temperature rises above the danger point.

Dasheens should be treated while dormant, since after they begin to sprout they are more easily injured by the hot water. For this reason, when they are not planted very early it is advisable to treat the tubers several weeks in advance of planting.

To avoid danger of introducing root-knot into land not already infested with it, all dasheens to be planted should be treated as above unless they are known to have been carefully examined at the time of digging and the fibrous feeding roots found free from all evidence of this disease. This examination to be of value must be made of the fresh roots, for it is only then that the characteristic "knots," galls, or swellings are easily and certainly recognized. Examination of the tubers at any other time is useless unless the infestation with nematodes is severe enough to cause distortion, in which case the tubers are not fit for seed.

THE HOME VEGETABLE GARDEN.

The southern home garden, especially in the sandy sections, is very generally, if not almost always, badly infested with root-knot, and because of the usual custom of having the garden in the same place year after year, combined with the fact that most garden vegetables are especially subject to nematode injury, it is relatively difficult to apply ordinary rotations successfully as a control measure.

ROTATE
CHICKEN YARD,
VEGETABLE GARDEN,
AND CORN PATCH.

For the southern home gardener who has had poor results with his summer vegetables due to root-knot, a special 3-year rotation has been worked out that has several points of advantage. It involves a rotation of the garden with the chicken yard, and assures better results with both. Only annual crops can be considered in this rotation. Perennials susceptible to root-knot, such as grapes and figs, must be planted in a separate area. The following plan or some modification of it suitable to special conditions is advised:

The back yard is divided into three parts lengthwise by means of woven-wire chicken fencing. The slope of the land should be such that there can be no drainage from one plat into another. The three parts may be designated A, B, and C (fig. 24). The chicken house is to be located in the middle at one end, as shown in the diagram, so that it can be made to open into any one of the three at will. Simple trap-door arrangements, as indicated in Figure 24, will provide for this. Leaving only one door open at a time, therefore, will permit the chickens to roam in only one yard.

The first year, say 1923, the garden is planted in plat A. The chickens are turned into plat B and are kept there as long as the garden is maintained. In plat C are planted only crops immune to root-knot, such as sweet corn for the home table. Cowpeas of the resistant varieties or velvet beans may be grown between the rows, and the soil will be improved. As early as possible in the fall a winter grain, such as Abruzzi rye, should be sown. This helps to keep down weeds that are susceptible to root-knot, and the rye affords valuable feed for the chickens in the spring.

Now rotate the fields each year. At garden planting time in the spring the chickens should be turned into the rye in plat C, where they will find good feeding for quite a while. If the flock is large enough the chickens will keep the ground bare of vegetation all summer long, and that is where they get in their good work of ridding the soil of the root-knot organism. Without a host plant the nematodes will die. Do not spoil the good results by throwing any nematodes over the fence to the chickens, either in the roots of even mildly attacked garden plants or in parings from affected plants, such as potatoes, used in the kitchen, unless they are cooked.

Plat A will be planted to corn and other immune crops in 1924 and serve as the chicken yard in 1925. Plat B will grow the garden in 1924 and will be followed in 1925 by the corn and other immune crops. Plat C will become the chicken yard in 1924 and serve as the garden the following year. After the two years of freedom from susceptible crops which this plat will then have had, the improvement with respect to nematodes will be evident.

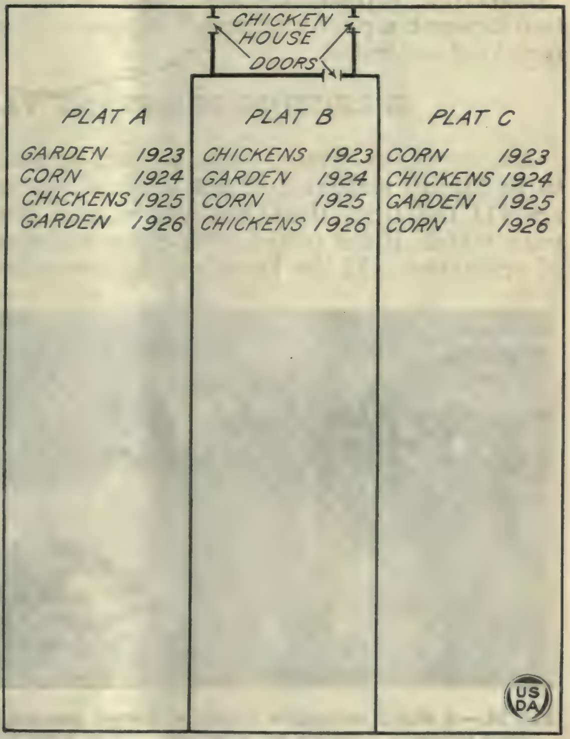

FIG. 24.—Plan of a home-garden, chicken-yard, and corn rotation which can be applied to available ground of almost any dimensions. Note the chicken house with doors opening into the three yards. A badly infested garden can be entirely freed from the root-knot nematode by applying the above rotation.

PREVENTION OF SOIL INFESTATION EASIER AND CHEAPER THAN CURE.

KEEP YOUR FIELDS FREE
AND AVOID LOSS AND EXPENSE.

Root-knot has become so widespread that it seems but a question of time until all lands where conditions are favorable will become infested unless special precautions are taken. First of all, the means by which the parasite is spread, listed on page 12, should be constantly guarded against. Particular care should be taken not to introduce the pest on seedling plants, bulbs, tubers, or nursery stock. Then the dangerous practice of growing susceptible crops year after year on the same ground should be stopped. As a preventive measure the crop rotations are especially recommended. They are even more certain to be productive of continuously good results in this connection than where they are used after infestation has already become severe, for in this latter case it is very easy to overlook susceptible weeds or volunteer plants from previous seasons that may keep the organisms alive until the susceptible " cash crop " is planted again. The old saying, "An ounce of prevention is worth a pound of cure," is especially applicable in the case of root-knot control.

SELECTING RESISTANT VARIETIES.

Among the cultivated crops certain strains or varieties are known to be highly resistant, if not immune, to nematode attack. These are (1) the Iron, Brabham, Victor, and Monetta varieties of cowpeas, which, if not mixed with other varieties, possess a high degree of resistance; (2) the Laredo and three other varieties of soy beans as yet not named; (3) American grapes, which are much more resistant than European varieties; and (4) certain kinds of figs (for example, the Celeste and Poulette are claimed to be less susceptible than other varieties). Hence, it is desirable that the more resistant strains be grown wherever possible, since this not only reduces the number of nematodes present in the soil but also insures better crops. Figue 25 illustrates differences in the susceptibility of cowpea varieties, while the striking resistance of the Laredo soy bean is shown in Figure 26.

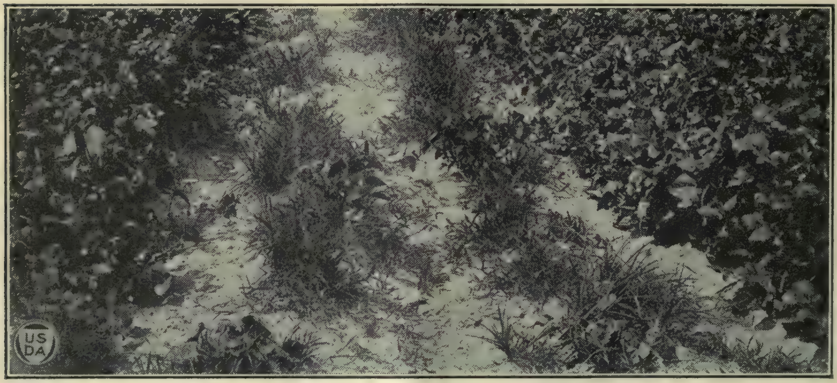

FIG. 25.—A highly susceptible variety of cowpea growing in the two middle rows, with more resistant varieties on either side. The susceptible variety was almost completely killed by root-knot, while the resistant varieties stood up vigorously.

As most of the above strains have been obtained by careful selection and breeding, it seems quite likely that other immune varieties can be developed in a similar way from crops which are now susceptible. Every farmer should be able to practice a simple selection, that is, when any plants in an infested field come up to standard in every way, are especially vigorous, and show freedom from root-knot, they should be marked and their seeds harvested separately. These seeds should be planted on infested land and similar careful seed selection should be made from the resulting disease-free plants.

More complicated breeding work, especially the crossing of immune upon susceptible varieties, is not advisable for the average farmer, on account of the time and expense.

As the most satisfactory and economical method of controlling root-knot depends upon the proper system of rotation with immune varieties of plants, it is highly important to keep pure the strains that are already known to be resistant and to strive to improve them by still further selections. Special care should be taken to prevent their crossing with susceptible varieties. Without these precautions even the best resistant sorts have been known to break down under severe root-knot conditions. It is also important that new strains of resistant crops be developed.

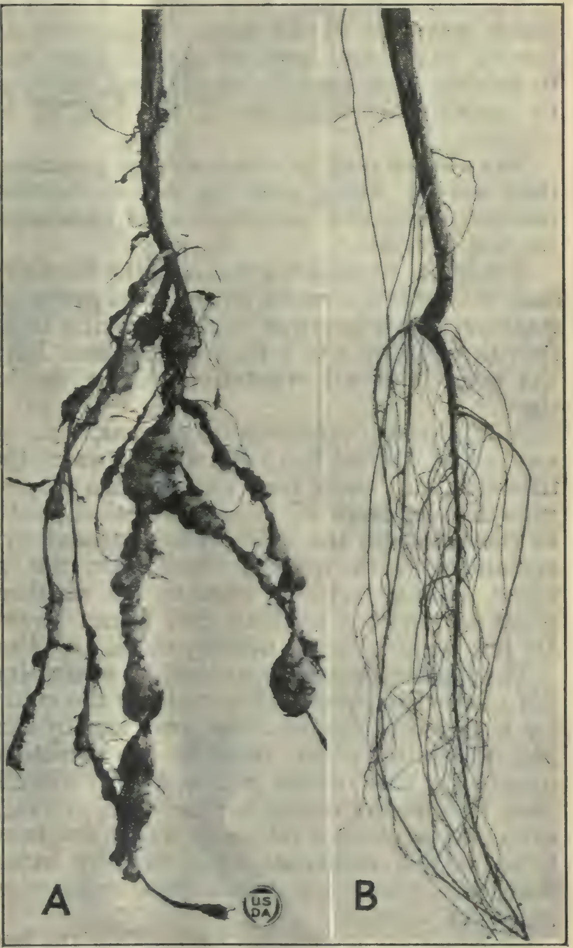

FIG. 26.—Roots of the Peking soy bean (*A*), a variety susceptible to root-knot, compared with those of the resistant variety Laredo (*B*). These plants were grown at Brooksville, Fla., under identical root-knot conditions. The resistant varieties are not always as free from the disease as is shown here.

SUMMARY.

A serious disease of plants known under the names of root-knot, root-gall, and big-root, causes immense damage in all except the most northern parts of this country.

The parasite causing the disease is a minute nematode, or eelworm (*Heterodera radicicola*), which multiplies very rapidly under favorable conditions. The life cycle may be completed in about four to five weeks, and each female may lay as many as 500 eggs. When invaded by the worms, roots become enlarged, distorted, or deformed, resulting in a hindrance to the growth of the plant.

Root-knot flourishes best in light, sandy soils which are moist and warm. It can not thrive in heavy soils or in those that are constantly wet.

Most crops are susceptible to the attacks of the disease. Some, however, are resistant. The most important of these are the Iron, Brabham, Victor, and Monetta cowpeas, corn, barley, beggarweed, rye, redtop, sorghum, the Laredo soy bean, timothy, velvet beans, wheat, and winter oats.

The nematodes may be transported from one locality to another in many ways, as in the roots of growing plants and by means of tubers, bulbs, and nursery stock. They can be carried from field to field by such agencies as running water and the soil which clings to agricultural implements, the feet of men, and the hoofs of animals.

The disease may be eliminated in greenhouses and seed beds when they are not being used by the application of steam under high pressure or by the introduction of uninfested soil into clean whitewashed benches.

The home vegetable garden of the South can very well be brought back into productiveness by a special grain, chicken-yard, and garden rotation. This requires chicken fencing to divide the available land into three parts and a flock of chickens large enough to keep down the growth of all vegetation within the inclosure designated for them.

In orchards, ornamental gardens, etc., no entirely satisfactory method of control has been worked out. Cultivation and high fertilization may cause trees to overcome the trouble by inducing rapid growth. In cases of local infestation, badly diseased trees should be removed and the infested soil treated with formaldehyde before replanting with healthy stock. Do not plant susceptible cover crops, as they rapidly increase the number of nematodes. Never plant an orchard on land that is not known to be nematode free. Do not plant infested nursery stock on either clean or infested soil.

The most satisfactory method of combating the nematode in fields not planted to perennial crops is by the cultivation of immune crops for a period of two to three years and by carefully killing all weeds and susceptible plants in which the nematode can live. A desirable rotation is that where winter grains alternate with resistant cowpeas, Laredo soy beans, velvet beans, or beggarweed. Care must be exercised to prevent drainage water, implements, animals, etc., from bringing the nematode from near-by infested fields. In ridding land of root-knot, plant only those crops which are known to be free from the disease.

Starving the nematodes by keeping the land free from all vegetation for two years is an effective control method, though often impracticable.

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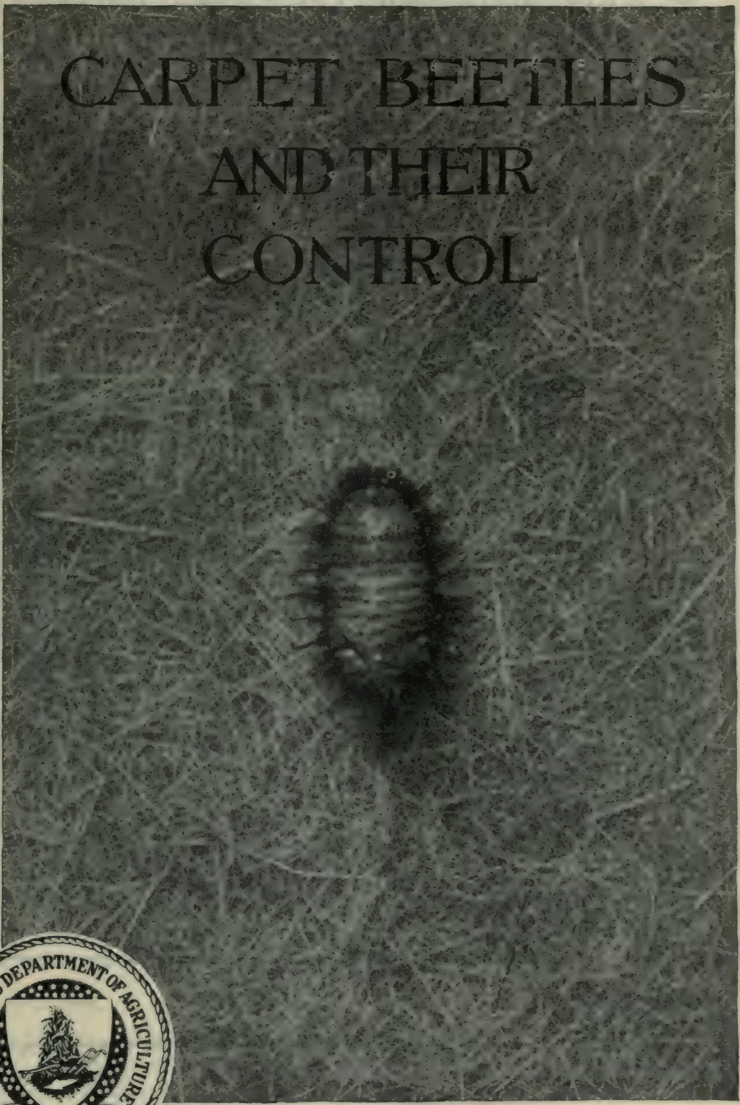
U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1346

CARPET BEETLES AND THEIR CONTROL



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CARPET BEETLES, or so-called "buffalo moths," are common household pests usually associated in their destructive work with clothes moths. Ordinarily they are not so destructive as clothes moths, because they reproduce only once a year, and then not so abundantly.

Experienced housewives throughout the North are familiar with the stout, oval, reddish-brown, hairy grubs or larvæ of the common carpet beetle, found beneath carpets or in clothing. In southern homes, however, the longer, slender, golden-brown larva of the black carpet beetle, with its tuft of golden bristles, is more common.

All carpet-beetle larvæ feed upon fabrics or upon various articles, including upholstered furniture, containing wool, silk, hair, fur, bristles, or feathers. They even feed upon dried animal matter.

Protection against carpet beetles can be secured in tight chests and trunks by the use of the crystals of naphthalene, paradichlorobenzene, or camphor, or by the fumigants carbon disulphid and carbon tetrachlorid. Where infestation is general throughout a house or is serious in closets, it may be advisable to fumigate with hydrocyanic-acid gas, carbon disulphid, or sulphur, but none of these fumigation methods should be employed except by a person well informed regarding them. The foregoing remedies and others, such as cold storage, red-cedar chests, heat, and the treatment of infested floor cracks, are discussed in this bulletin.

Washington, D. C. July, 1923

CARPET BEETLES AND THEIR CONTROL.

By E. A. Back, *Entomologist in Charge of Stored-Product Insect Investigations, Bureau of Entomology.*

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CARPET BEETLES OR "BUFFALO MOTHS."

THE so-called "buffalo moths" are not moths; they are beetles and very distinct from the true clothes moths. In this country there are six species,[1] at least, that attack museum materials and household fabrics, but of these only four [2] have proved serious household pests in America. All species are capable of subsisting upon dried animal remains, and thrive upon them perhaps as well as upon the fine fabrics of wool, hair, feathers, fur, and silk.

Carpet beetles pass through life cycles, or generations, consisting of egg, larva or grub, pupa, and adult or beetle. These stages differ greatly in appearance. The beetles are broadly oval and about three-sixteenths to one-fourth of an inch long; black, but with this blackness often obscured by tiny red, orange, brown, yellow, or white scales which form color designs characteristic of the species. These scales, which are modified hairs, are easily rubbed off, revealing the black color of the body beneath. The larvæ, or grubs (as the larvæ of beetles are often called) are brownish or black and variously clothed with stiff hairs, as shown in Figures 1 and 8, or with a long tuft of hairs at the end of the body, as shown in Figure 5. Carpet beetles pass through not more than two generations annually, and more often only one, and there are records of certain individuals requiring much longer, even three years, to complete their growth. The following accounts are given of the four most important species.

THE COMMON CARPET BEETLE.[3]

The common carpet beetle was known as *the* carpet beetle in the years following its introduction into America when floors were more commonly than now covered entirely with carpets that were tacked down along the edges, thus giving the larvæ an undisturbed shelter favorable to their development. Originally a pest in Europe, where it is still common, it was introduced into this country about 1874, probably at Boston and New York simultaneously. No stage of this common carpet beetle is longer than three-sixteenths to one-fourth of an inch. The general proportions of larva, pupa, and adult are shown in Figure 1. The rich reddish brown larvæ are clothed with stiff dark brown hairs which are longer around the sides, and still longer at the ends, than upon the back.

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[1] *Anthrenus scrophulariae* L., *A. museorum* L., *A. fasciatus* Hbst., *A. lepidus* LeC., *A. verbasci* L., and *Attagenus piceus* Oliv.

[2] *Anthrenus scrophulariae* L., *A. verbasci* L., *A. fasciatus* Hbst., and *Attagenus piceus* Oliv.

[3] *Anthrenus scrophulariae* L.

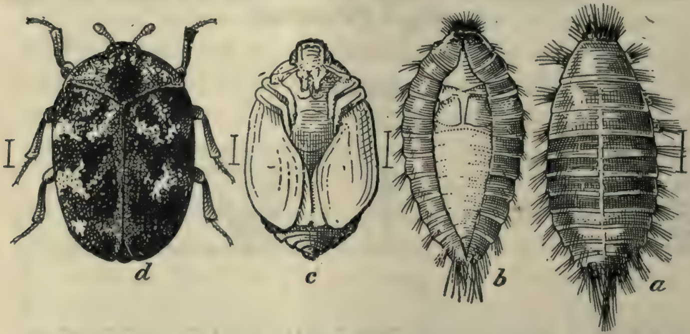

FIG. 1.—The common carpet beetle: *a*, Larva, dorsal view; *b*, pupa within larval skin; *c*, pupa, ventral view; *d*, adult. All enlarged (Riley.)

The larvæ feed upon carpets and woolens (Fig. 2), furs, feathers (Fig. 3), bristles, and silks. They remain secluded in dark places, hidden beneath carpets or in the folds of garments. They eat irregular holes in fabrics, but in carpets tacked to floors they are more likely to eat slits following cracks. They never cause a webbing on the fabric.

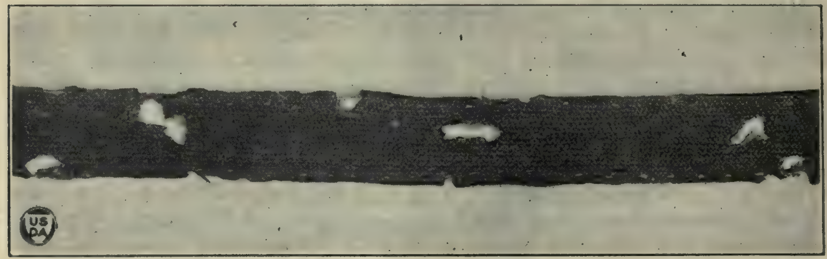

FIG. 2.—Typical carpet beetle damage to woolen cloth. For injury to feathers see Fig. 3.

While most conspicuous in the Northern States, this carpet beetle is frequently found in the latitude of Washington, D. C., and southward. Specimens have recently been sent from Texas and Florida. In a Washington storehouse the contents of a trunk closed for several years were found badly damaged by the larvæ.

The following account [4] is just as applicable to-day as when written many years ago.

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[4] Howard, L. O., in Bulletin 4, new series, Division of Entomology, United States Department of Agriculture, pp. 58–59. 1896.

The adult insect is a small, broad-oval beetle, about three-sixteenths of an inch long, black in color, but is covered with exceedingly minute scales, which give it a marbled black-and-white appearance. It also has a red stripe down the middle of the back, widening into projections at three intervals. When disturbed it "plays 'possum," folding up its legs and antennæ and feigning death. As a general thing the beetles begin to appear in the fall, and continue to issue, in heated houses, throughout the winter and following spring. Soon after issuing they pair, and the females lay their eggs in convenient spots. The eggs hatch, under favorable conditions, in a few days, and the larvæ, with plenty of food, develop quite rapidly. Their development is retarded by cold weather or lack of food, and they remain alive in the larval state, in such conditions, and particularly in a dry atmosphere, for an almost indefinite period, molting frequently and feeding upon their cast skins. Under normal conditions, however, the skin is cast about six times, and there are, probably, in the North, not more than two annual generations. When the larva reaches full growth the yellowish pupa is formed within the last larval skin. Eventually this skin splits down the back and reveals the pupa, from which the beetle emerges later. The beetles are day fliers, and when not engaged in egg laying are attracted to the light. They fly to the windows, and may often be found upon the sills or panes. Where they can fly out through an open window they do so, and are strongly attracted to the flowers of certain plants, particularly the family Scrophulariaceæ, but also to certain Compositæ, such as milfoil (*Achillea millefolium*). The flowers of Spiræa are also strongly attractive to the beetles. It is probable, however, that this migration from the house takes place, under ordinary circumstances, after the eggs have been laid.

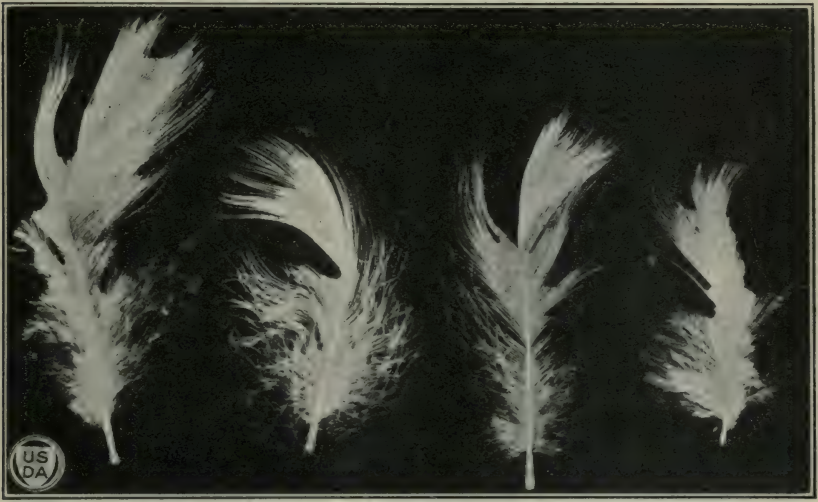

FIG. 3.—Feathers damaged by fabric pests. Injury has been done here by clothes moths and carpet beetles. They reduce feathers to a mat-like mass.

In Europe the insect is not especially noted as a household pest, probably owing to the fact that carpets are seldom tacked down. In fact, the writer believes that only where carpets are extensively used in this way are the conditions favorable for the great increase of this insect. Carpets once tacked down are seldom taken up for a year, and in the meantime the insect develops uninterruptedly. With the more general use of polished floors, and rugs which are often taken up and beaten, there is little doubt that the "buffalo bug" will eventually cease to be a household insect of importance. The insect is known in Europe as infesting museums, but has not acquired this habit to any great extent in this country. It is known to have this habit in Cambridge, Mass., and Detroit, Mich., as well as in San Francisco, Calif., but not in other localities. In each of these three cases it was imported from Europe in insect collections.

THE BLACK CARPET BEETLE.[5]

The black carpet beetle derives its common name from the black, unadorned color of the adult. Its larva is reddish or golden brown, long and slender, with a characteristic tuft of long hairs at the end of its body. It curls up and "plays 'possum" when disturbed. A glance at Figure 5 will be sufficient for the identification of this unique carpet-beetle larva.

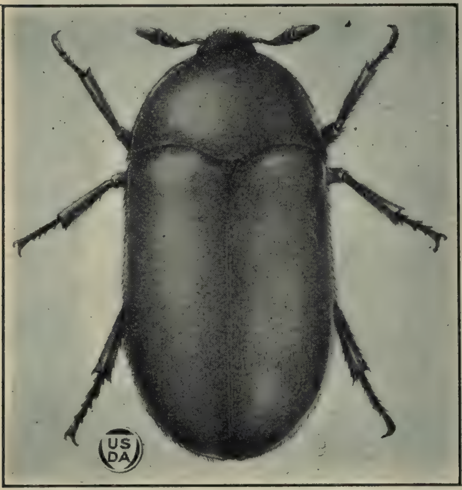

FIG. 4.—Black carpet beetle: Dorsal view of adult beetle. Greatly enlarged.

Widespread in Europe and Asia, it first attracted attention in America in 1854. Since then it has become widely distributed throughout the United States, often being the most injurious of the carpet beetles, especially in the more southern States. It is the carpet beetle most commonly referred by housewives to the department for identification. It feeds upon household fabrics of wool, feathers, fur, hair, and silk, and also upon cereals and cereal products, seeds, and dried animal remains, hence has many opportunities for existence in warehouses and barns as well as in houses.

The adult.—The adult of the black carpet beetle is small, oval, and black, as shown in Figure 4. The adults are present in abundance only during the early summer. In a steam-heated building at Washington, D. C., large numbers of adults were present late in April and during May, but became rather scarce during the first part of June, although single adults were found as late as early in July. The adult flies readily and is often seen crawling on window panes and screens. It is during the adult stage that the black carpet beetle spreads most easily from house to house.

The female beetle lays small, white, fragile eggs upon fabrics, in floor cracks, or in any sheltered spot near its food. The length of life of the parent insect ranges from 3 to 35 days during April, May, and June. Seldom are adults found later than July, except in very warm storage houses.

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[5] *Attagenus piceus* Oliv.

The egg.—The fragile white eggs are very seldom seen, and hatch in warm weather in about 6 to 10 days.

The larva.—The golden brown larva, with short, stiff body hairs, and its long tuft of hairs at the end of the body (Fig. 5), attains a length of one-fourth of an inch, exclusive of the tuft of hair at the end of the body. When first hatched it is almost microscopic in size, but increases rapidly under favorable food and climatic conditions. As it grows it sheds its skin from five to eleven times, and possibly oftener. This is of interest, for frequently the cast skins are mistaken for the insect itself, thus unnecessarily alarming the housewife concerning the abundance of this carpet beetle. It requires approximately one year for larvæ to become fully grown when fed upon casein. Larvæ hatching during early June and fed upon casein became full grown and transformed to the adult stage during the following April, May, and June. Larvæ fed upon woolen cloth and silk and flour and meal were still only partially grown at the end of one year, indicating that the black carpet beetle may require two years for its development. In India it has been found that certain of these larvæ may require from one to three years for growth.

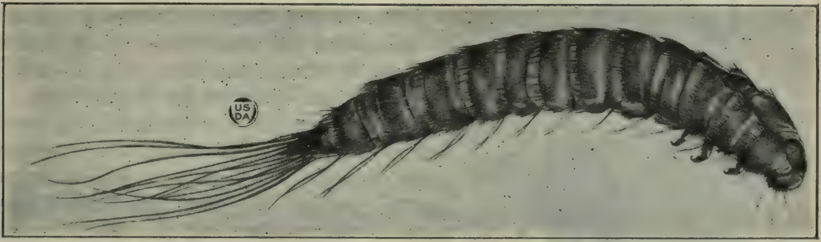

FIG. 5.—Black carpet beetle: Larval skin showing the typical shape of the larva and the long tuft of bristles at the end of the body. Greatly enlarged.

The pupa.—In the pupa stage the insect is white, clothed with fine white hairs (Fig. 6), and helpless. The pupa stage continues from 6 to 16 days during early summer at Washington, D. C., and is seldom found at any other season of the year.

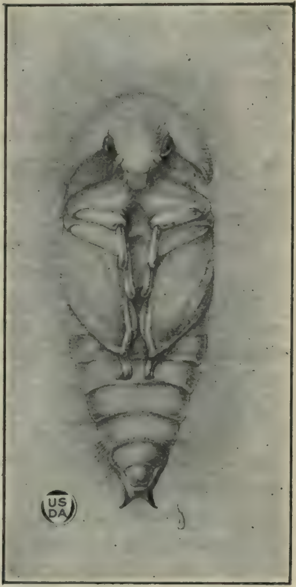

FIG. 6.—Black carpet beetle: Ventral view of pupa. Greatly enlarged.

Seasonal history.—Since the greater part of the life cycle is passed in the larva stage, the facts previously mentioned indicate that the black carpet beetle may have only one generation each year, although it may require two or three years for the same development. From the observation of the writer, made in houses, warehouses, and in the laboratory at Washington, there seems little doubt that a very large percentage of the insects have one generation each year. Farther north, or under less favorable climatic and food conditions, a generation may require two or even three years. At any rate, the adults are on the wing during early summer and the eggs for new infestations are laid then.

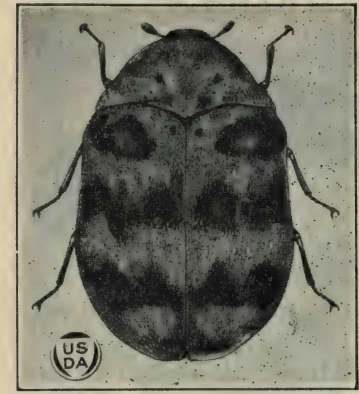

FIG. 7.—The varied carpet beetle: Dorsal view. Greatly enlarged.

THE VARIED CARPET BEETLE.[6]

The varied carpet beetle is similar in shape to the common carpet beetle,[7] but is a trifle smaller. It is called the "varied" carpet beetle because the color pattern on the back of the beetle varies considerably with the arrangement of the white, brownish, and yellowish scales. Figure 7 presents a common arrangement of the scales. The underside of the body is thickly clothed with white scales. This insect is a European pest now well established in widely separated parts of the United States. It has been found more often perhaps feeding upon seeds in museums than upon clothing, though its larvæ do attack woolen goods, feathers, hair, and silks.

The larvæ are not unlike other carpet beetle larvæ of the genus Anthrenus. In Figures 8 and 9 are shown the newly hatched and the mature larvæ. When unmutilated, they possess on each side at the end of the body three dense tufts of bristles and hairs. If suddenly alarmed, the larvæ erect these tufts and spread the bristles and hairs out so as to form beautiful round balls.

During late spring and early summer, when the insect transforms to the adult stage in greatest numbers, the adults are driven by instinct to seek the bright sunshine and the pollen of certain flowers. In this respect they are not unlike other species of carpet beetles, the adults of which may be found also upon flowers. Some think that Viburnum or Spiraea bushes planted near the house will lure carpet beetles from the house. It is probably true, however, that the beetles, before leaving the house, lay a large percentage of their eggs, so that the attraction the sun and flowers have for them is of so little practical value to the householder that it is not worth while to depend upon flowers to lure the adults from the house.

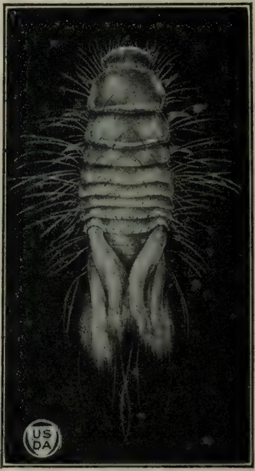

FIG. 8.—Varied carpet beetle: Dorsal view of newly hatched larva. Greatly enlarged.

The varied carpet beetle in the adult stage flies about in tremendous numbers. During May, 1922, the writer could capture them by the thousands upon at least 30 species of flowers found in public gardens in Washington, D. C. Single white roses often attracted more than 100 beetles, while a single stalk of a common herbaceous Spiraea harbored more than 1,000 specimens. The beetles often fly in large numbers rather high above the ground. A gentleman[8] after painting a portion of the tin roof of his house during early May returned 24 hours later to complete the painting, only to find that during the interim an average of two varied carpet beetles to the square inch had become entangled in the fresh paint. The writer observed two adults fly into his city apartment in Washington through an open window during early March, 1922. These flights of adults are of extreme importance to the householder, because they emphasize how readily carpet beetles may spread from house to house during spring and early summer. Window screens will exclude all except the smallest specimens if they fit tightly, but the average removable screen does not fit tightly enough to prevent adult carpet beetles from crawling into the house between screen and window frame.

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[6] *Anthrenus verbasci* L.
[7] *Anthrenus scrophulariae* L.

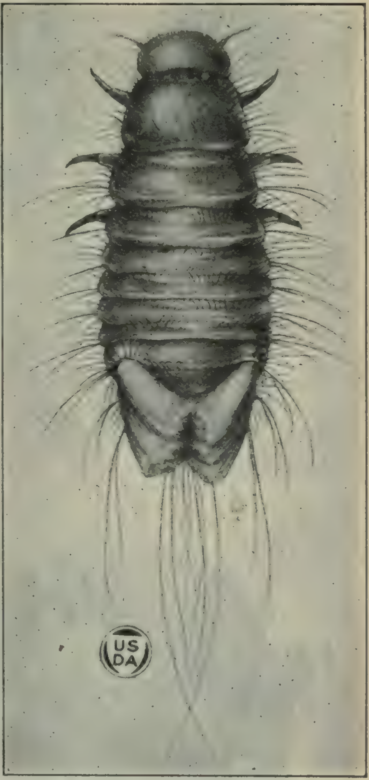

FIG. 9.—The varied carpet beetle: Dorsal view of well-grown larva. Greatly enlarged.

THE FURNITURE CARPET BEETLE.[9]

The carpet beetle or dermestid[10] here discussed has had no common name, but may be called the furniture carpet beetle (Fig. 10). It, too, is a European pest introduced into this country. It has been reported from Algeria, Spain, Greece, southern Russia, Mesopotamia, and the East Indies. It was first recognized in America during 1911, from specimens sent the American Museum of Natural History, New York City, from an upholsterer in Augusta, Ga. The specimens were taken from the curled hair of furniture upholstered 12 to 15 years previous to 1911. Investigation indicated that the hair used in this furniture came from Russia. The pest was not again noted in America until April, 1915, when it was found seriously damaging an upholstered chair in the White House. Since then, particularly during the last several years, many pieces of furniture and mattresses in different sections have been reported badly damaged.

In all instances the furniture was upholstered with curled hair and moss, and in some cases the hair had been completely devoured by the larvæ, in association with smaller numbers of the common carpet beetle, the black carpet beetle, and the webbing clothes moth. (Figs. 11 and 12.)

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[8] H. S. Barber.

[9] *Anthrenus fasciatus* Herbst.

[10] So called because, like the other carpet beetles, it belongs to the family Dermestidae.

This beetle is now well established in this country and is a most serious furniture pest. The adults eat holes through heavy leather and linen coverings, while the larvæ reduce the hair used in the upholstering to a mass of cast larval skins and ground-up hair. The hair then has the appearance of black gritty dirt which can be scraped up by the handful, if not by the pailful. When the larvæ become abundant in a piece of furniture they may drop to the floor and there feed upon rugs and other fabrics made of wool, hair, fur, or feathers. The larvæ or grubs are seldom seen unless searched for, but the adults, because of their habit of flight during March to June (in Washington), leave the furniture and crawl about the furnishings and windows, and while hardly one-fourth of an inch long, are made conspicuous by the brown, white, and yellow scales that cover their bodies.

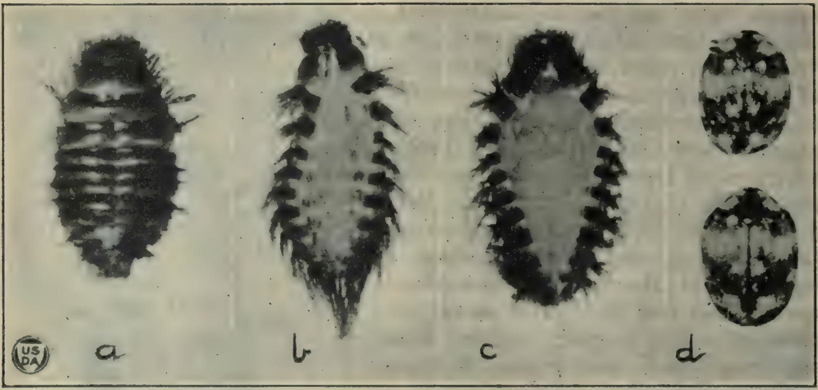

FIG. 10.—The furniture carpet beetle: *a*, Well-grown larva; *b*, larval skin; *c*, pupa within larval skin; *d*, two beetles.

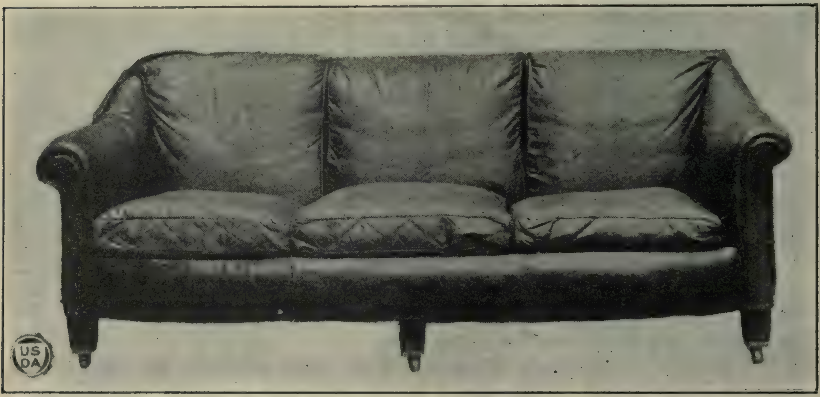

FIG. 11.—Upholstered furniture sometimes harbors thousands of clothes moths and carpet beetles without showing evidence of their feeding until they have become very abundant. From this couch thousands of adult carpet beetles were found emerging and spreading about the house. Only reupholstering or fumigation will rid such a piece of furniture of pests.

For a general impression of the appearance of the furniture carpet beetle see Figure 10. The adult may live several weeks. The female has been known to lay as many as 36 eggs in one day. Fortunately this species does not seem to be very prolific, since no adult has been known to lay more than 85 eggs. The eggs are small, white, easily crushed by brushing, and are laid in the nap of clothing. In furniture coverings of mohair, plush, and similar materials the eggs are tucked down in the pile, as shown in Figure 13. The eggs hatch during warm summer weather in from 12 to 15 days. The larvæ require the rest of the year for growth and do not transform to the adult until the following spring. The larvæ, however, do not all grow equally well, and some specimens may require only one year for development, while others may remain for considerable periods somewhat dormant, even in the presence of much food, and will not transform to the adult until much later, sometimes as long as one year after others, hatching on the same day, have matured.

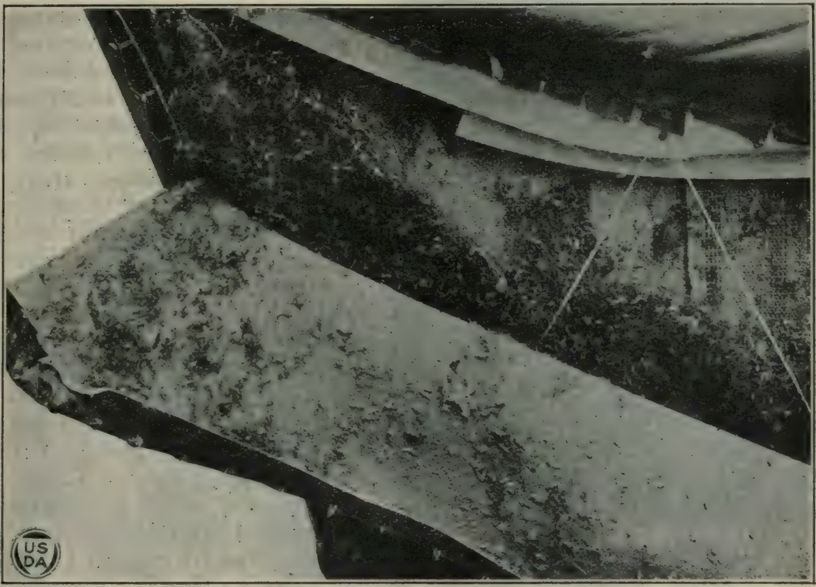

FIG. 12.—Leather covering at end of couch shown in Figure 11, loosened to expose the work of the furniture carpet beetle. Note that this pest, working with fewer numbers of clothes moths and black carpet beetles, has eaten nearly all the curled hair stuffing, leaving behind the moss used with the hair, countless larval skins, and handfuls of a fine, gritty, dirtlike substance which is nothing more nor less than the frass of the insect. Thousands of carpet beetles can mature in such furniture without the knowledge of the casual observer. It is only when the stuffing is eaten away and the pests leave the furniture and crawl about the house that suspicion is centered upon furniture as the possible source of an unending supply of clothes moths and carpet beetles that appear here and there about the house.

CONTROL MEASURES.

The measures to be used for the control of carpet beetles depend upon the place in the house where the pest is causing injury. If carpet beetles are troublesome in trunks, chests, or closets that are not opened often, a good grade of flake naphthalene, paradichlorobenzene, or camphor will give good results. If the trouble is in closets in daily use, beneath carpets or rugs, or in piano felts or upholstered furniture, these substances are of practically no value, and one must fumigate the house as a whole or in part with either hydrocyanic-acid gas, carbon disulphid, or carbon tetrachlorid, or use the still older, more tedious, and less effective means of control consisting in frequent search for and the killing of the individual larvæ and adults, and the treatment of floor cracks and similar hiding places with kerosene, gasoline, or benzine. The following materials and methods may be employed with satisfactory results:

FIG. 13.—Eggs of the furniture carpet beetle laid in the pile of a plush mohair covering of a chair. Considerably enlarged; the eggs are smaller than the head of a common pin and white in color.

NAPHTHALENE.

Naphthalene in the form of flakes (preferably) or moth balls is effective when used at the rate of one-half to 1 pound to each 10 to 13 cubic feet of space. It is always better to use a larger rather than a smaller quantity of these crystals. Great care should be exercised to keep tightly closed the trunks or chests of clothing with which the naphthalene is stored. Naphthalene in chests opened frequently or those carelessly left open for hours at a time, or in chests with large cracks or warped covers, is not to be depended upon. Naphthalene should be of good grade. It is best to purchase it put up in unbroken tin cans of 1 pound or more capacity. Remember that naphthalene kills all stages of the carpet beetles by means of the fumes given off during the slow evaporation of its crystals and it is essential that these fumes be closely confined. Naphthalene in bureau drawers, in closets frequently used, scattered upon closet shelves, or beneath carpets is not to be depended upon for absolute protection.

PARADICHLOROBENZENE.

Paradichlorobenzene crystals are similar in general appearance to those of naphthalene. The fumes given off by the slow evaporation of the crystals in a tightly closed container will kill all stages of the carpet beetle, if about 1 pound of crystals is used for each 10 cubic feet of space.

CAMPHOR.

Camphor is not as quickly effective against all stages of carpet beetles as are naphthalene and paradichlorobenzene. Its action is slower. Use from one-half to 1 pound for each trunk of about 10 cubic feet capacity.

RED-CEDAR CHESTS.

Chests made of red cedar, popularly known as Virginia[11] or Tennessee red cedar, if well constructed, will kill the very young larvæ of carpet beetles. They will not kill the beetles, the older larvæ, or the pupæ, nor will they prevent the eggs from hatching. The writer has known larvæ of the black carpet beetle[12] to remain apparently unaffected in a red-cedar chest from June of one year to May of the following year, and then to transform normally to the adult stage. The older larvæ of carpet beetles can be removed from clothing before it is stored in chests by thorough brushing. It is valuable to know that red-cedar chests will kill the very young larvæ. It should always be remembered that articles such as balls of yarn, floor skins backed with woolen cloth, pillows stuffed with hair or feathers, and similar objects in the interior of which the older carpet-beetle larvæ can hide should not be placed in cedar chests until fumigated to kill the larvæ hidden where they can not be reached by brushing.

COLD STORAGE.

One of the safest methods of preventing loss through carpet-beetle attack is to store susceptible articles with a reliable cold-storage firm maintaining rooms for such purposes at a temperature of 50° F. or lower.

FUMIGATION.

Carpet beetles, as well as all other household pests, can be eliminated as disturbing factors by fumigation within as short a time as three or four hours (if necessary). Fumigation with formaldehyde candles, although excellent for killing disease germs, is worthless for insect control, and the public is warned accordingly. Sulphur fumes will kill many carpet beetles, but very few persons succeed in killing all carpet beetles with sulphur fumes. Sulphur should be burned at the rate of 13½ ounces per 1,000 cubic feet of space. It is likely to bleach wall paper and fine fabrics and tarnish metals, and should never be used unless one is aware of these possible bad results.

Hydrocyanic-acid gas.—Hydrocyanic-acid gas is the best gas known and in present use for the fumigation of houses, or parts of houses, for the speedy elimination of carpet beetles or other pests. When persons are troubled with fabric pests that have become generally established throughout the house, nothing will give greater satisfaction in peace of mind and freedom from trouble than one thorough fumigation carried on by a professional fumigator or by any intelligent, careful person capable of following directions. Hydrocyanic-acid gas is dangerous to human beings, but is noninflammable and nonexplosive as used in household fumigation as here advocated. It is lighter than air, will injure no fabric or painting, and will not tarnish household metals. If properly used, it is one of the simplest and best methods of fighting house pests. Interested persons can have full particulars free of cost by writing the Division of Publications, Department of Agriculture, for Farmers' Bulletin 699.

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[11] *Juniperus virginiana.*
[12] *Attagnus piceus.*

Carbon disulphid.—Carbon disulphid is a fumigant in general use for killing insects of all sorts in containers that are reasonably tight. It is excellent for killing carpet beetles in chests, trunks, and closets that can be closed and sealed. It has been used for the fumigation of entire buildings when these are detached. It is purchased at drug stores or of chemical firms as a liquid put up in tin cans containing 1, 2, 5, or 10 pounds each. Upon exposure to the air, the liquid evaporates, forming a gas heavier than air which sinks through the container being fumigated and kills the insects by suffocation. The gas is explosive in the presence of fire, and must be handled with the same care as gasoline or benzine. Although the liquid as purchased is considered not explosive or inflammable, great care should be exercised in storing and handling it since it is almost impossible to dissociate it from its gas, which is, as stated above, decidedly explosive and inflammable in the presence of fire. The odor of carbon disulphid gas is very disagreeable, but soon disappears with the airing of the container after fumigation. Carbon disulphid fumigation is excellent for the destruction of carpet beetles in articles that can be stored in trunks, chests, or closets, or for killing pests in pianos and upholstered furniture that can be placed in a small room for the period of fumigation. Full particulars regarding this fumigant and the ease with which it can be used may be had by writing the Division of Publications, Department of Agriculture, for Farmers' Bulletin 799.

Carbon tetrachlorid.—Carbon tetrachlorid is used in exactly the same way and for the same purpose as carbon disulphid, except that from two to three times as much of the liquid must be used to fumigate the same amount of space. Carbon tetrachlorid is not a particularly effective fumigant, but it has the advantage of producing, upon evaporation, a gas that is noninflammable and nonexplosive, and for this reason can be used in certain places where lighted lamps, fires, etc., can not be entirely eliminated. See Farmers' Bulletin 799 for reference to use of carbon tetrachlorid and carbon disulphid.

MISCELLANEOUS CONTROL MEASURES.

Laundering and dry cleaning.—When material infested with carpet beetles is submerged in a solution of 1 pound of neutral soap to 10 gallons of water all stages of the beetles are killed. Carpet-beetle larvæ are killed if subjected to temperatures of 120, 125, and 128° F. for 30, 15, and 10 minutes, respectively. Eggs are killed when subjected to temperatures of 125 and 130° F. for 16 and 11 minutes, respectively. Eggs and larvæ were killed in material dipped for 5 seconds in water at 140° F., but submergence for the same period in water at a temperature of 122° F. failed to kill all of them. Translated into household terms this means that laundering clothing or other textiles in thick suds or with water hotter than the hand can bear, or pressing with a hot iron, will probably kill the larvæ and eggs of the carpet beetle. The usual commercial dry-cleaning processes also are probably effective. Unfortunately these methods are not always easily applied to the articles most likely to be infested; they must not be considered a preventive against reinfestation.

Treatment of floor cracks and other hiding places.—Carpet-beetle larvæ often secrete themselves in the cracks of flooring, beneath base boards, and in other openings about houses formed by the usual shrinking or settling of woodwork. The larvæ feed upon the lint which gathers in such places. It is, therefore, an excellent procedure to have all such openings closed where possible by filling in with putty or patented crack-fillers. Any cracks that can not be filled in this manner should be periodically filled with gasoline, kerosene, or benzine to kill larvæ. Since these liquids are inflammable, care must be exercised not to have lighted lamps or fire in any form about until after the rooms are well ventilated.

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U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1347

Superseded by no. 1506

STANDARD VARIETIES OF CHICKENS

I. THE AMERICAN CLASS

1862 1889

THE American class includes the Plymouth Rock, Wyandotte, Java, Dominique, Rhode Island Red, Rhode Island White, Buckeye, Jersey Black Giant, and Chantecler.

The fowls of these breeds are commonly called general-purpose fowls, because they are not only good egg producers but their carcasses are also well suited for the table. They are therefore the breeds best suited for the general farm flock, and include some of the most popular and widely kept varieties of chickens. They are in good favor with the poultry packers on account of their table qualities.

All the American breeds lay brown-shelled eggs. They all have yellow skins and shanks free from feathers, which are desirable qualities for table fowl in this country.

In size they are intermediate between the smaller egg breeds, such as the Leghorns, and the larger meat breeds, such as the Brahmas. The Jersey Black Giants, however, are about as large as the meat breeds. In temperament the American breeds are also intermediate, being less active than the egg breeds but more so than the meat breeds. They are fairly good foragers.

They mature earlier than the meat breeds, but not so quickly as the egg breeds.

They are sitters and make good mothers. Where they are kept, natural methods of incubation and brooding can therefore be used.

A general description of the different standard breeds and varieties of the American class is given in this bulletin.

This bulletin is a revision of and supersedes Farmers' Bulletin 806.

Washington, D. C. July, 1923

STANDARD VARIETIES OF CHICKENS:
THE AMERICAN CLASS.

By **Rob R. Slocum**, *formerly of the Animal Husbandry Division, Bureau of Animal Industry.*[1]

(Revised by Alfred R. Lee, Poultryman, Animal Husbandry Division.)

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PRACTICALLY every farm in the United States keeps chickens. In the majority of instances the flock of poultry is kept merely as a side line, to utilize material which otherwise would go to waste, and to furnish eggs and meat for the farmer's table. At many seasons of the year the flock will produce a large surplus over what is needed for the farmer's own use, and this when sold yields a considerable income, sometimes sufficient to pay for the groceries and wholly or in part to clothe the family.

THE KIND OF CHICKEN THE FARMER WANTS.

To meet these demands the farmer therefore desires a breed or variety of chickens which are not only good layers, but also have size enough to provide suitable carcasses for the table. The breeds which meet these two demands are commonly called the general-purpose breeds, and in the main are those comprising the American class as given in the American Standard of Perfection. The Orpington, belonging to the English class, is also a well-known general-purpose breed in this country. The general-purpose breeds are undoubtedly the most popular breeds in the United States. Certain of these, namely, the Plymouth Rocks, Wyandottes, Rhode Island Reds, Orpingtons, and Jersey Black Giants, compose the bulk of purebred poultry kept on the general farms, and their blood is evident in most of the farm flocks.

CHARACTERISTICS OF THE GENERAL-PURPOSE BREEDS.

In size the general-purpose breeds are intermediate between the meat breeds, such as the Brahmas, and the egg breeds, such as the

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[1] Mr. Slocum resigned October 11, 1921.

Leghorns. They are of a much quieter temperament than the egg breeds, and for that reason are more easily handled in confinement. They mature earlier than the meat breeds, but not so quickly as the lighter egg breeds. In activity and ability to "rustle" for a living they are again intermediate between the meat and the egg breeds, but are good foragers. Because of the fact that they fatten readily and are of a fair size they are very popular with the poultry packer, and sell to better advantage in those localities where the farmer is compelled to look to the poultry packer for a market for his fowls.

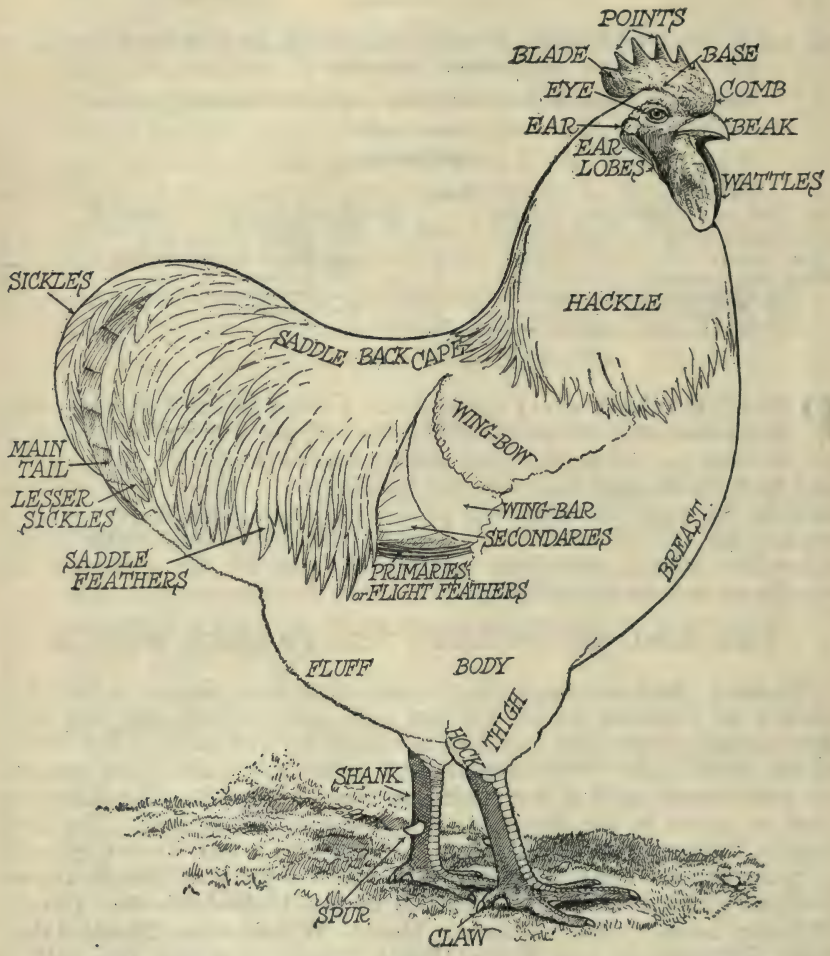

FIG. 1.—Glossary chart giving the names of the various sections of a male fowl.

Because of the tendency for the general-purpose breeds to put on fat much more readily than the egg breeds, they must be fed more carefully when kept in confinement; otherwise there is a tendency for them to "break down behind"—in other words, to accumulate an excessive amount of fat in the abdominal region. Where the fowls have free range, however, this trouble is not likely to occur.

They are sitters and make good mothers. This is an important consideration where the farmer keeps only a small flock and does not wish to invest money in hatching and brooding equipment. These birds are layers of brown eggs. In consequence, they are not so suitable for conditions where a premium is paid for white eggs; under such conditions, where large poultry farms have been established, the White Leghorn has come to be the most popular fowl.

All the American breeds are clean legged; that is, they have shanks free from feathers. They also have yellow legs and skin, except the Java and the Jersey Black Giant, in which the legs are black or leaden blue and yellow. In the markets of the United States the former is a desirable point, as the demand is for yellow skin and legs in table fowls.

BREEDS AND VARIETIES.

The American class includes the following standard breeds and varieties:

BREEDS.	VARIETIES.
Plymouth Rock	Barred, White, Buff, Silver Penciled, Partridge, Columbian, Blue.
Wyandotte	White, Buff, Silver, Golden, Partridge, Silver Penciled, Columbian, Black.
Java	Black, Mottled.
Dominique.	
Rhode Island Red	Single Comb, Rose Comb.
Rhode Island White	Rose Comb.
Buckeye.	
Jersey Black Giant.	
Chantecler.	

In describing these breeds and varieties it is the intention to give only a general statement of their appearance and characteristics. For a description sufficiently detailed to enable one to breed exhibition specimens it will be necessary to refer to the American Standard of Perfection, a book published by the American Poultry Association, which is the guide by which all the poultry shows in the United States are judged.

THE PLYMOUTH ROCK.

The Plymouth Rock has been for years the most popular breed in the United States. The Barred Plymouth Rock was the original variety and was developed in the United States, various lines of blood being used in the making. It is probable that the Dominique, the Black Cochin, the Black Java, the Brahma, and the Pit Game were used for this purpose. The size and type or shape of all the varieties of Plymouth Rocks are supposed to be identical. In general the breed may be described as a good-sized, rather long-bodied chicken, with fairly prominent breast and good depth of body, showing when dressed a well-rounded, compact carcass. This breed has a single comb and yellow legs, bill, and skin. The standard weight of cocks is 9½ pounds; of hens, 7½ pounds; cockerels, 8 pounds; pullets, 6 pounds. They are layers of good-sized, brown-shelled eggs, and are reputed especially as winter layers.

The Barred Plymouth Rock (Figs. 2, 3, 4, and 5) is by far the most popular general-purpose or farm fowl. This variety has so long been a favorite with the general public that the barred color is generally associated with quality in table fowls. The Barred Plymouth Rock plumage is a grayish white, each feather of which is crossed by dark bars which are almost black. It is desired that these bars should be as even in width, as parallel, as straight, and as well carried down to the skin as possible. Each feather should end with a narrow, dark tip. The barring in the hackle and saddle is narrower than in other sections. The alternating dark and light bars give a bluish cast or shade to the general color, which should be even throughout the surface. It is common for solid black feathers or feathers which are partly black to occur in practically all strains in this variety, but this should not be taken as a sign of impure breeding. Black spots

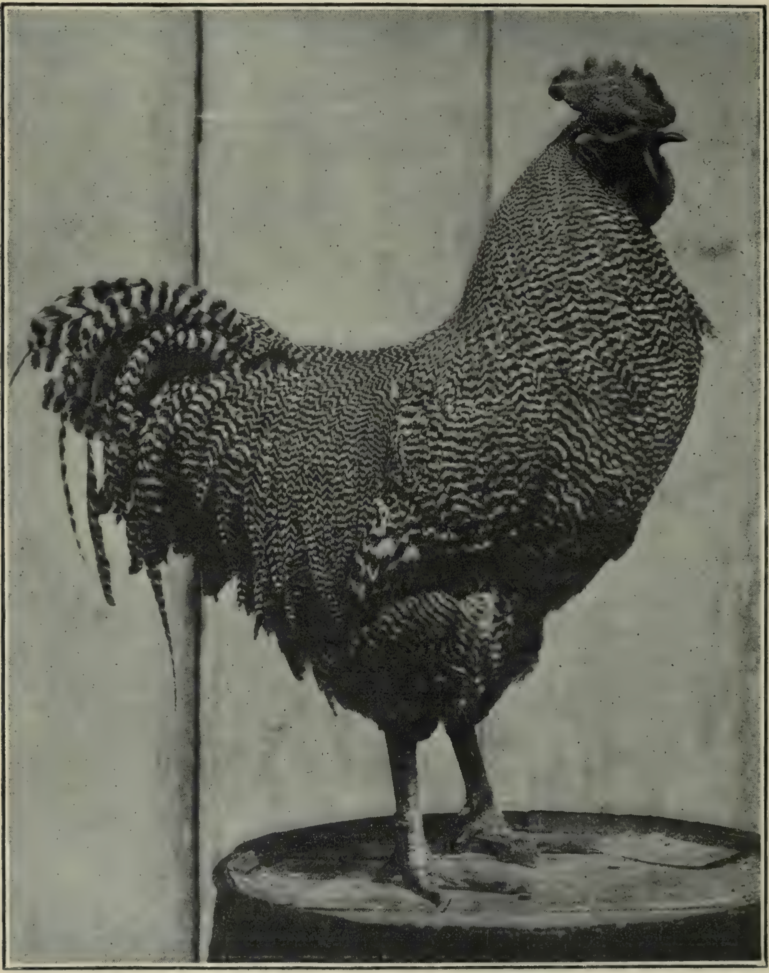

FIG. 2.—Exhibition or cockerel-bred Barred Plymouth Rock, male.

are also common occurrences on the shanks, particularly in females, but this does not indicate impurity.

There is a decided tendency for the males of this variety to come lighter in color than the females, and for this reason breeders are usually obliged to resort to two separate matings, one for the production of males of standard or exhibition color and the other for the production of females of standard or exhibition color. This system of breeding is known as double mating. In mating for males of exhibition color a male of about standard color is used with medium dark females, or those two or three shades darker than females of exhibition color, in which the barring is as distinct and as narrow as possible, showing a clear-cut line between the black and white bars. This mating is known as the cockerel mating, because it produces a greater percentage of exhibition or standard-colored males, while the females produced are too dark in color for exhibition, but are suitable for continuing this line of breeding. In mating for females of exhibition color, females of about standard color are used with a medium light male or one that is two or three shades lighter than males of exhibition color, but which shows distinct barring and as strong barring in the undercolor as can be obtained. This mating is

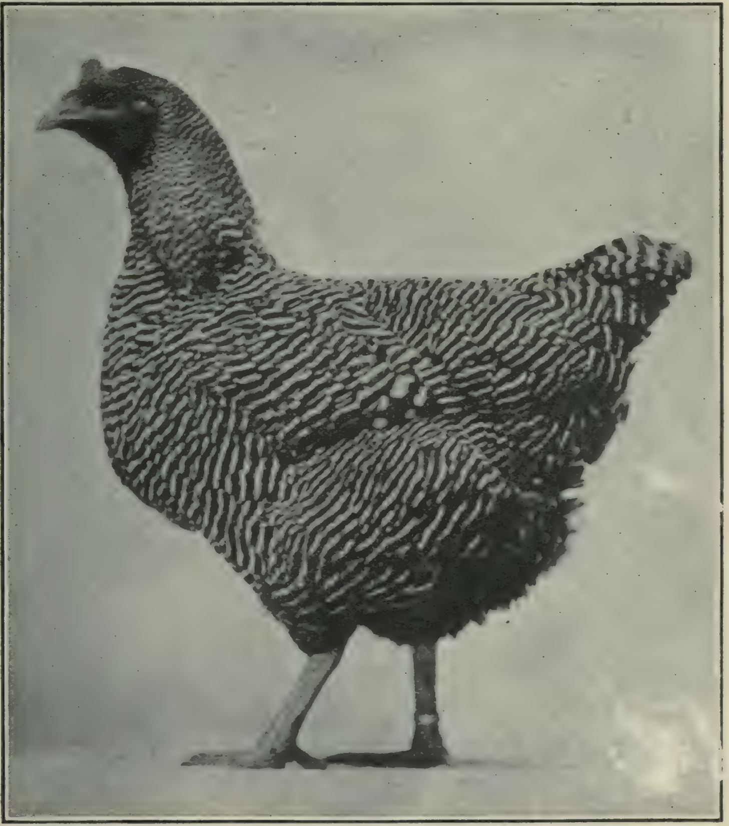

FIG. 3.—Cockerel-bred Barred Plymouth Rock, female.

known as the pullet mating, because it produces a greater percentage of females of exhibition color, while the males produced are too light for exhibition, but may be used to continue this line of breeding. Several of the poultry shows in the United States have two separate classes in the Barred Plymouth Rocks, one for dark barred and one for light barred, in which both males and females are exhibited.

The White Plymouth Rock (see illustration on title page) is the second most popular variety of this breed. All the characteristics of the White Plymouth Rock are supposed to be identical with those of the Barred Plymouth Rock except color. As a matter of fact the White Plymouth Rock tends to run somewhat larger in size, and the type is a little more uniform and a little better than that of the Barred Plymouth Rock. In color the White Plymouth Rock should be a pure white throughout, free from black ticking and from any brassiness or creaminess.

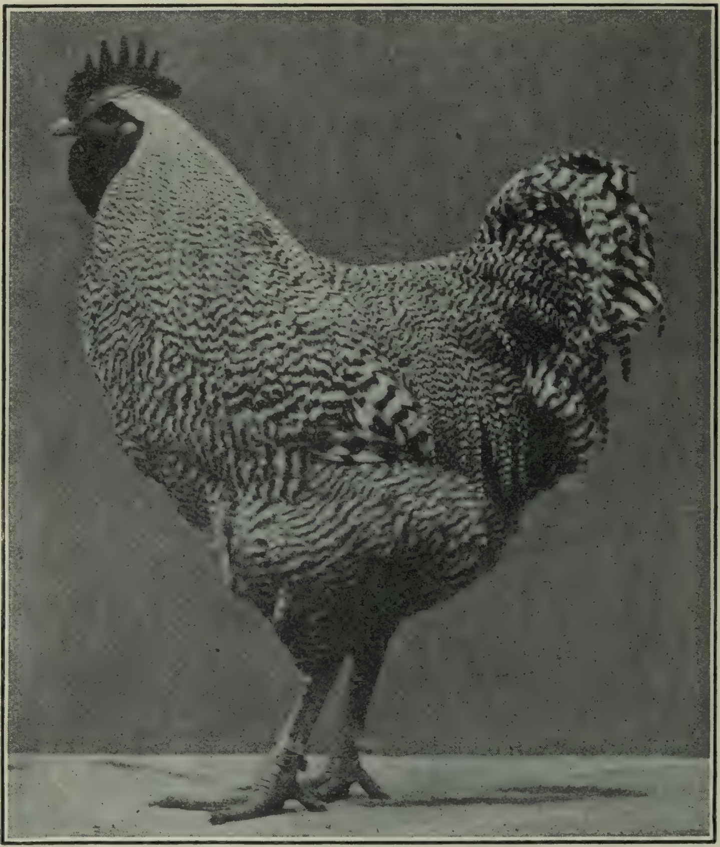

FIG. 4.—Pullet-bred Barred Plymouth Rock, male.

The Buff Plymouth Rock is distinguished from the other Rocks by the color alone, which should be an even shade of golden buff throughout. Shafting, or the presence of feathers having a shaft of different color from the rest of the feather, and mealiness, or the presence of feathers sprinkled with lighter color as though powdered with meal, are undesirable. As deep an undercolor of buff as it is possible to obtain is desirable. There is a great difference of opinion as to what constitutes desirable buff color, some favoring the lighter color, approaching lemon, while others favor a much darker buff, approaching red. The important point is to have the shade as even as possible over the entire surface.

The Silver Penciled Plymouth Rock is one of the new varieties. Its plumage is distinctive and very beautiful. In general, the plumage of the male consists of a silver-white top color, extending over the shoulders and back, the hackle and saddle striped with black. The rest of the body plumage, including the main tail feathers and sickles, is black. The wings when folded show a bar of black extending across below the shoulder. Below this the wing shows white, due to the white on the outside of the secondaries. In the female the general trend of color is gray, with delicate, distinct, concentric penciling of dark on each feather except the hackle, each feather of which is silvery white with a black center, showing a slight gray penciling, and the main tail feathers, which are black, with the two top feathers showing some penciling. The color of the plumage is practically the same as that of the Dark Brahma.

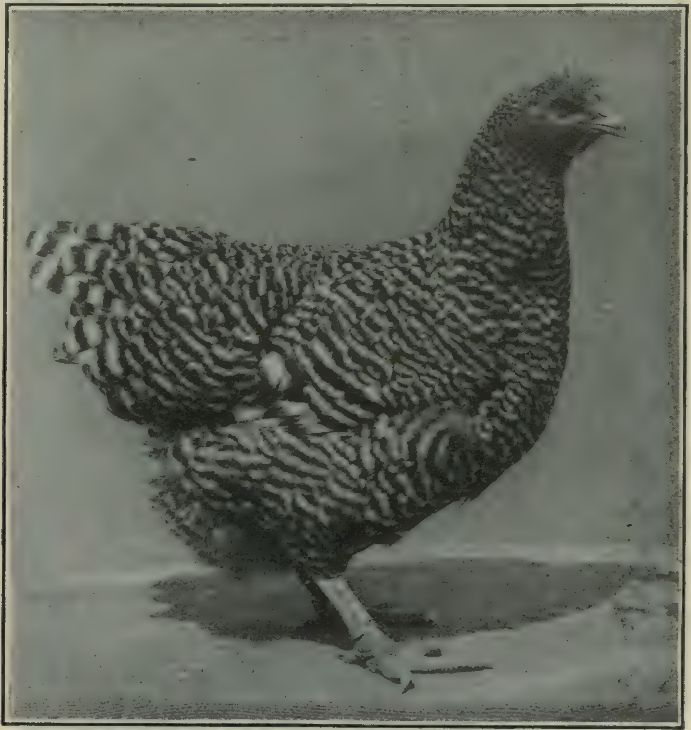

FIG. 5.—Exhibition or pullet-bred Barred Plymouth Rock, female.

The Partridge Plymouth Rock is also one of the newer varieties of this breed. The coloring of this variety is very attractive and is practically the same as that of the Partridge Cochin and also of the Silver Penciled Plymouth Rock, except that the white of the Silver Penciled is replaced by red or reddish brown.

The Columbian Plymouth Rock, a variety of comparatively recent origin, is very attractive in coloring and has proved quite popular. In general the color is white, the hackle feathers being black with a narrow edging of white, and the main tail feathers black, the tail coverts being black with a distinct white lacing. The wings also carry some black on the primary and secondary feathers, which is almost hidden when the wings are folded. The color of this variety is practically the same as that of the Light Brahma.

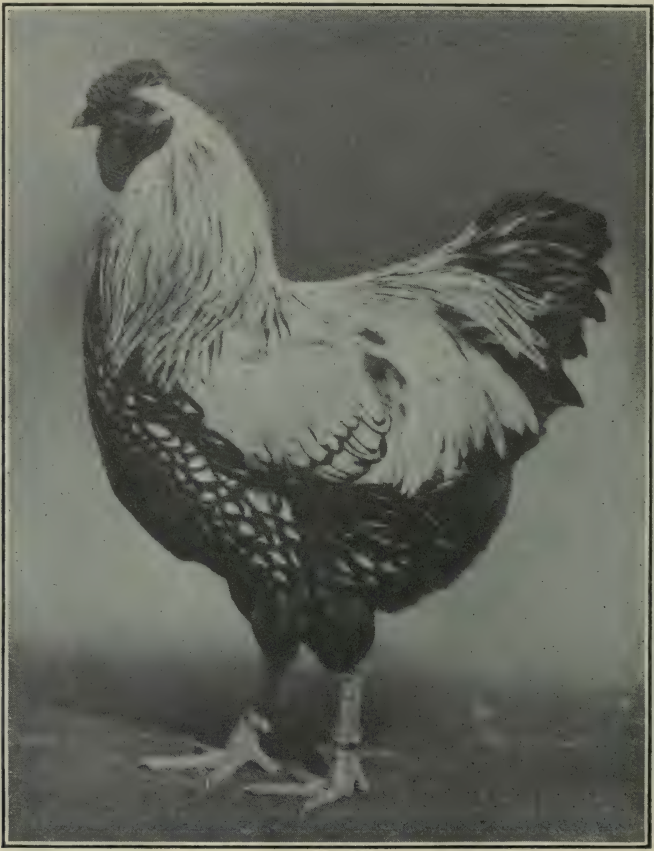

FIG. 6.—Silver Wyandotte, male.

The Blue Plymouth Rock is a recent variety obtained by crossing the Blue Andalusian on the Barred Plymouth Rock. This variety should have typical Plymouth Rock type combined with Blue Andalusian color. This breed has general characters similar to those of the other varieties of Plymouth Rocks. A general top color of dark, lustrous blue, approaching black, is the standard for the male. This color extends over the hackle, back, saddle, shoulders, sickle feathers, and tail coverts. The rest of the plumage is a slaty blue showing a well-defined lacing of darker blue in all sections. In the female the general plumage color is a slaty blue of even shade, each feather except the primaries having a clear, well-defined, narrow lacing of darker blue similar to the breast color of the male. The neck is decidedly darker than the rest of the body color. Both sexes have a slaty blue undercolor.

THE WYANDOTTE.

The Wyandotte is a rose-comb breed and is characterized as a breed of curves. The body is comparatively round and set somewhat lower on the legs than the Plymouth Rock. It is inclined to be a looser-feathered breed, and its general shape and character of feathering gives it an appearance of being somewhat short backed and short bodied. The Wyandotte is a breed which also was developed in the United States, and has become very popular. The Silver Wyandotte was the original variety, and it is generally believed that the Dark Brahma, the Silver-Spangled Hamburg, and the Buff Cochin played a part in its origin. It is somewhat smaller than the Plymouth Rock, the standard weight being, for the cock, 8½ pounds; hen, 6½ pounds; cockerel, 7½ pounds; pullet, 5½ pounds. The hens are fairly prolific

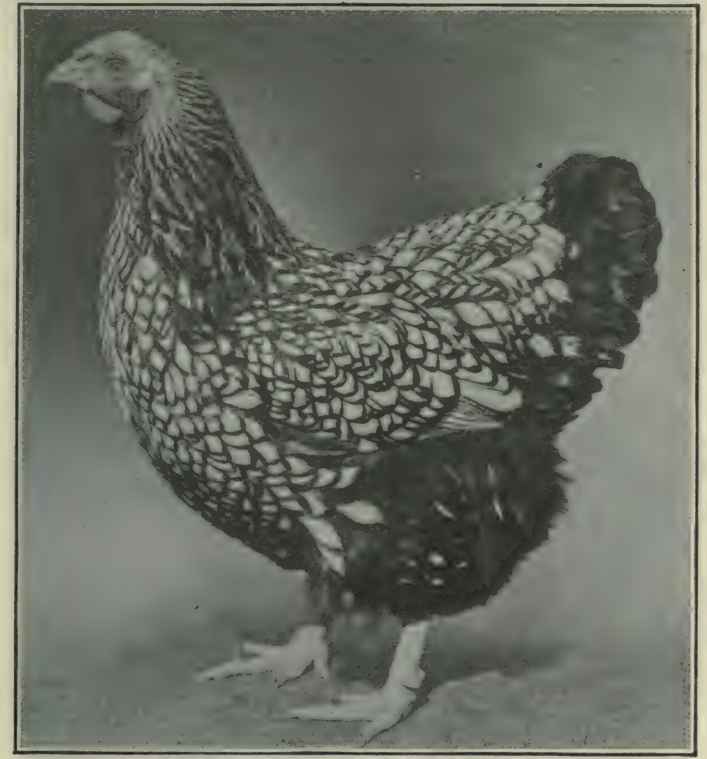

FIG. 7.—Silver Wyandotte, female.

layers of brown eggs, are reputed to be good winter layers, and the breed as a whole makes a fine table fowl. The young chickens do not tend to have the same leggy stage which is characteristic of the Rocks and most of the other general-purpose breeds, and the breed is therefore well suited for the production of broilers. Like the Plymouth Rock, all the varieties of this breed are yellow legged and yellow skinned, which adds to their market popularity.

In the Silver Wyandotte (Figs. 6 and 7) the male has a silver-white back and saddle, the hackle and saddle feathers being striped with black. The feathers of the body and breast are white, each laced with a black edge. The main tail feathers are black. The fluff is a slate color with some gray mixture. The color of the female shows white feathers laced with black over the entire body except the hackle, which is black laced with white, and the main tail feathers, which are black, and some black in the wings, while the fluff is slate mixed with gray. The color combination and the character of markings of the Silver Wyandotte make this a very attractive variety.

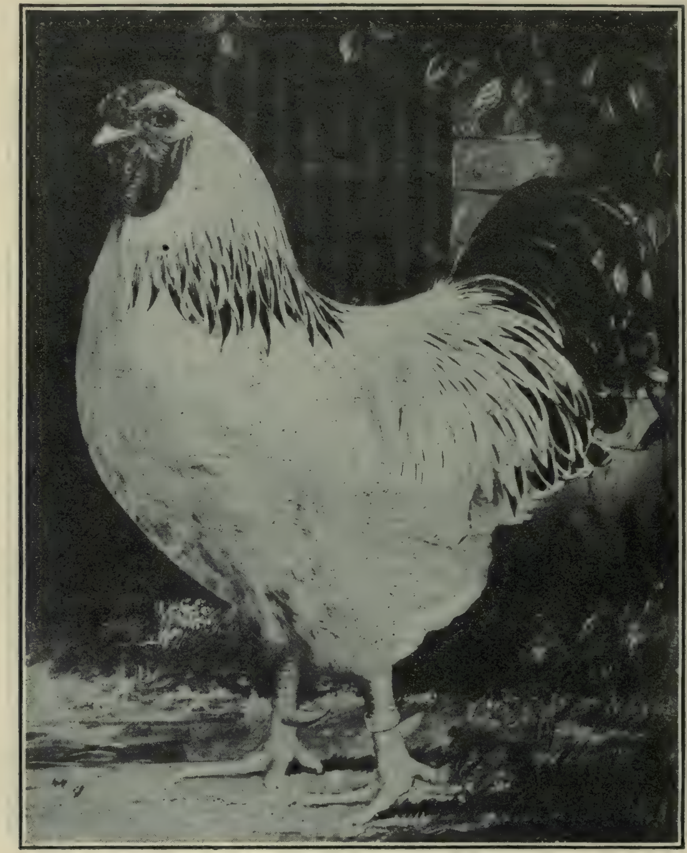

FIG. 8.—Columbian Wyandotte, male.

In the Golden Wyandotte the general color scheme is the same as in the Silver Wyandotte, except that the white of the Silver variety is replaced with red and reddish brown. Like the Silver Wyandotte, the color and markings of the Golden are very attractive.

The White Wyandotte is undoubtedly the most popular variety of this breed. The color is white throughout, and should be free from any brassiness or creaminess or black ticking.

In the Buff Wyandotte the color should be an even shade of buff throughout, being identical with that of the Buff Plymouth Rock.

In the Black Wyandotte the color is black in all sections, showing a greenish sheen, free from purple barring. The undercolor is lighter, somewhat on the slate order.

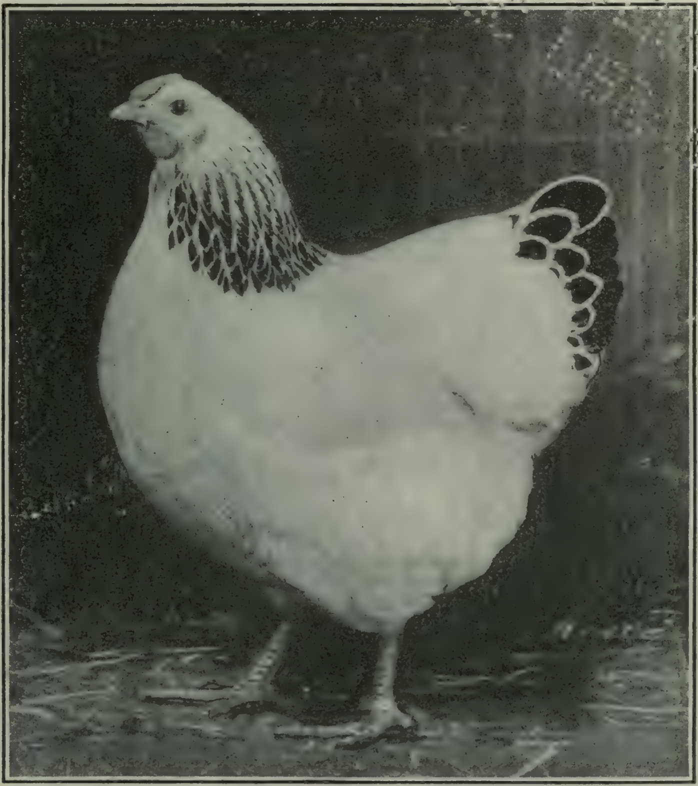

FIG. 9.—Columbian Wyandotte, female.

In the Partridge Wyandotte the color is the same as in the Partridge Plymouth Rock. In the Silver-Penciled and Columbian Wyandottes (Figs. 8 and 9) the color is the same as in the corresponding varieties of the Plymouth Rocks.

THE JAVA.

The Java is one of the oldest breeds developed in the United States. In general this fowl tends to be long in body and broad in back. The comb is single, and the legs of the Black variety are black, or black approaching yellow, while those of the Mottled variety are yellow and leaden blue. The color of the legs detracts somewhat from the fowl for market purposes. The skin, however, is yellow. The hens are good layers of brown-shelled eggs, and the fowls are suitable for table purposes. This breed is not very commonly found at the present time. The standard weights are: Cock, 9½ pounds; hen, 7½ pounds; cockerel, 8 pounds; pullet, 6½ pounds.

There are two varieties of Javas, the Black and the Mottled. The color of the Black Java is black throughout, with a greenish sheen on the surface plumage. Purple barring is undesirable. In the Mottled Java the plumage is a mottled black and white throughout, the black being more plentiful than the white. The undercolor of the Mottled Java is slaty.

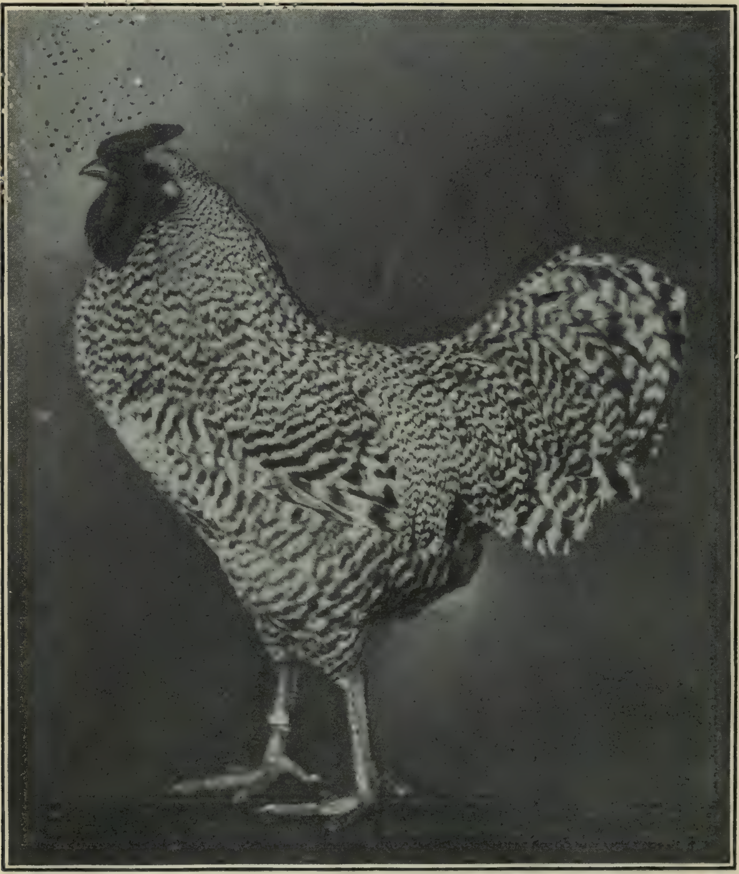

FIG. 10.—Dominique, male.

THE DOMINIQUE.

The Dominique (Figs. 10 and 11) is also one of the oldest of the American breeds. The Dominique color is associated in the minds of people throughout the country with the barnyard fowl and is frequently confused with the Barred Plymouth Rock color. The Dominique is somewhat smaller and somewhat slighter in body, with a tail somewhat longer and sickles more prominent, than the other American breeds. This breed has a rose comb and yellow legs and skin. The hens lay brown-shelled eggs and are good table fowls, although somewhat smaller than the other general-purpose breeds. The standard weights for this breed are: Cock, 7 pounds; hen, 5 pounds; cockerel, 6 pounds; pullet, 4 pounds. The purebred Dominique is not extensively kept at the present time in the United States.

In color of plumage the Dominique has a general bluish or slaty cast, the feathers in all sections being barred throughout with alternate, rather irregular, dark and light bars. The markings somewhat resemble those of the Barred Plymouth Rock, but are less distinct, and lack the clean-cut character of the Plymouth Rock barring. Like the Barred Plymouth Rock, each feather should end with a dark tip. The Dominique male may be, and often is, one or two shades lighter than the female. Slate undercolor occurs throughout.

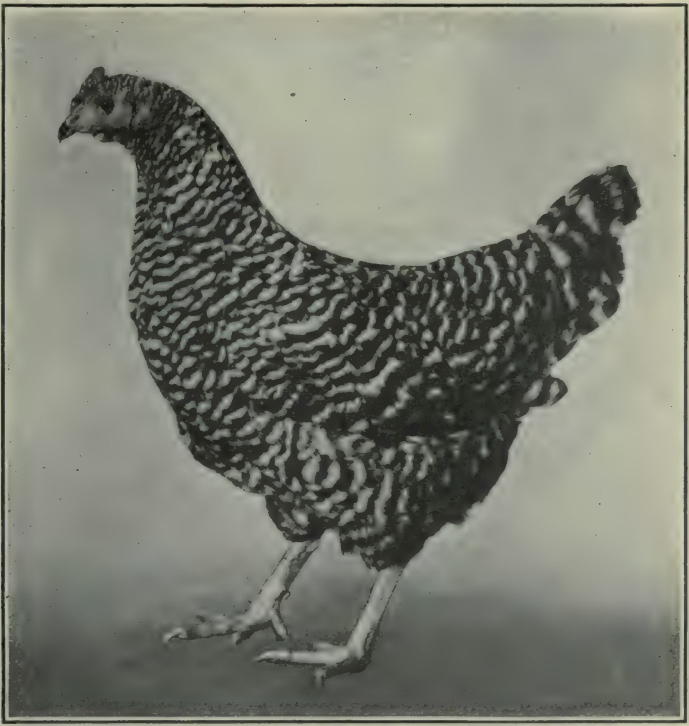

FIG. 11.—Dominique, female.

THE RHODE ISLAND RED.

The Rhode Island Red (Figs. 12 and 13) is one of the newer breeds which have been developed in this country. At the present time it bears an excellent reputation among the farmers and is kept very extensively throughout the farming districts. The breed originated in Rhode Island, where it was developed by the farmers engaged in poultry raising. The Malay, Buff Cochin, Buff Leghorn, and Wyandotte are said to have been used in its development.

In type the Rhode Island Red has a rather long, rectangular body and is somewhat rangier in appearance than the Plymouth Rock or the Wyandotte. The hens are prolific layers of brown-shelled eggs, and the breed makes a very suitable table fowl, having yellow legs and yellow skin. The Rhode Island Reds have enjoyed an excellent reputation for hardiness, which, in the main, they have well deserved. The standard weights for this breed are: Cock, 8½ pounds; hen, 6½ pounds; cockerel, 7½ pounds; pullet, 5 pounds.

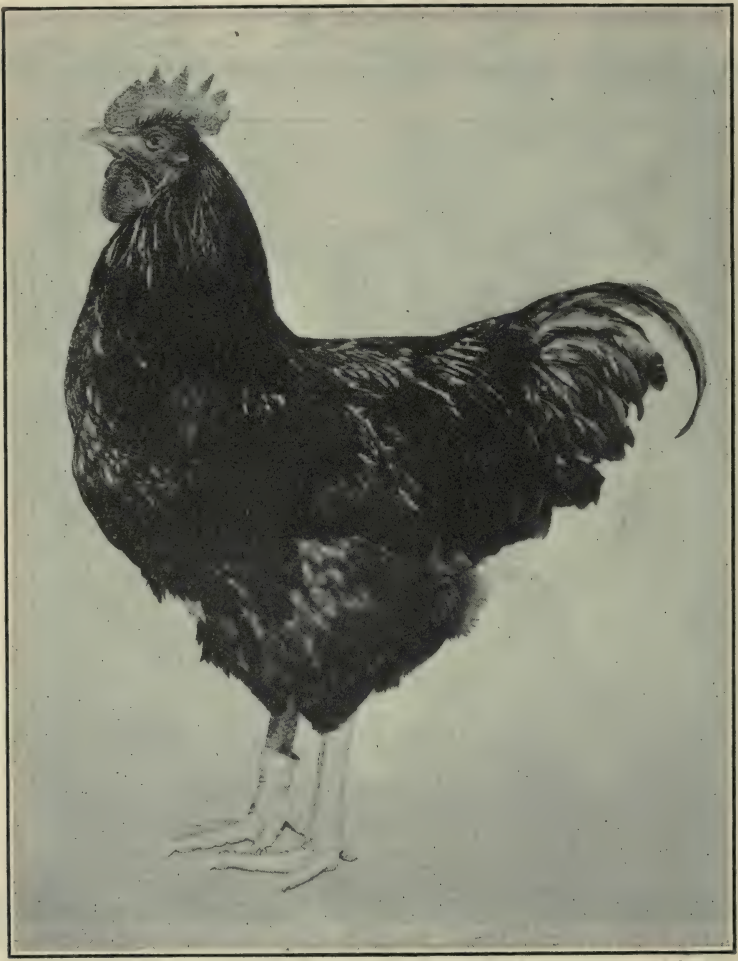

FIG. 12.—Single-Comb Rhode Island Red, male.

There are two varieties of the Rhode Island Red which are identical in color and type, but one of which has a single comb and the other a rose comb.

In color the Rhode Island Red is a rich, dark red, approaching a mahogany. It is desired to have this color as even as possible over the entire surface. There is a tendency, however, for the hackle and the lower part of the saddle of the male to be lighter in color than the back and shoulders. The main tail feathers in both sexes are black, and the wings also show some black. In the hackle of the female there is also a slight ticking of black. The undercolor of all sections should be red, and free from a dark or slaty appearance, which is known as smut.

THE RHODE ISLAND WHITE.

The Rose-Comb Rhode Island White has recently been admitted to the American class. The type and other characteristics are identical with the Rose-Comb Rhode Island Red, except that the plumage should be of pure white color, free from any tint of brassiness. This variety was before the public a number of years before it was admitted to the American Standard. It has the desirable qualities of a general-purpose breed found in the Rhode Island Red. Good type is essential, as otherwise specimens of this breed may be mistaken for White Wyandottes.

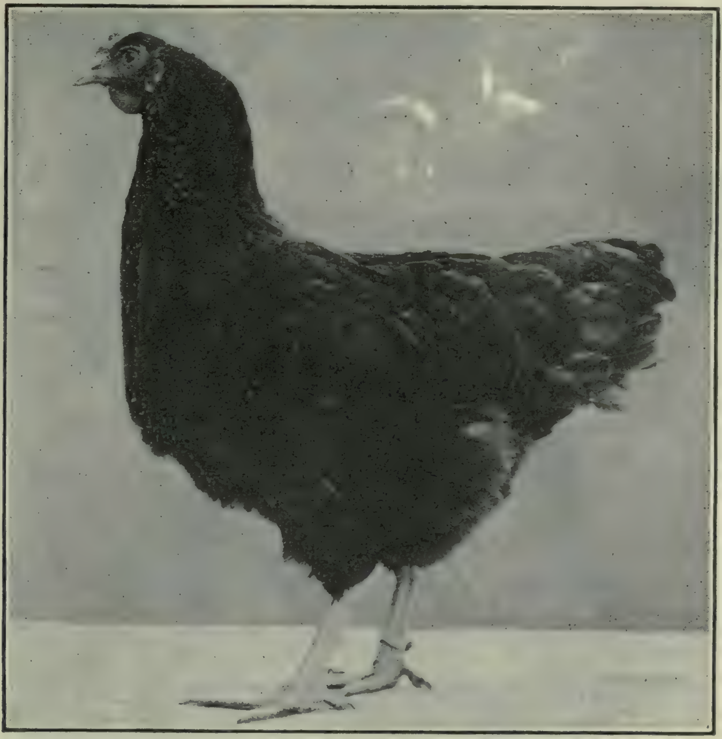

FIG. 13.—Rhode Island Red, female.

THE BUCKEYE.

The Buckeyes are an American breed of comparatively recent origin. In type they approach somewhat to the Cornish, being erect and broad-breasted. The standard weights are: Cock, 9 pounds; hen, 6½ pounds; cockerel, 8 pounds; pullet, 5½ pounds. This breed has a pea comb, which doubtless comes from the Cornish blood used in originating it. The hens lay brown eggs. In color Buckeyes are mahogany bay, which is slightly darker on the wing bows of the males. The flight and tail feathers often carry black as well. The undercolor should be red, except in the back, where a bar of slate is desired.

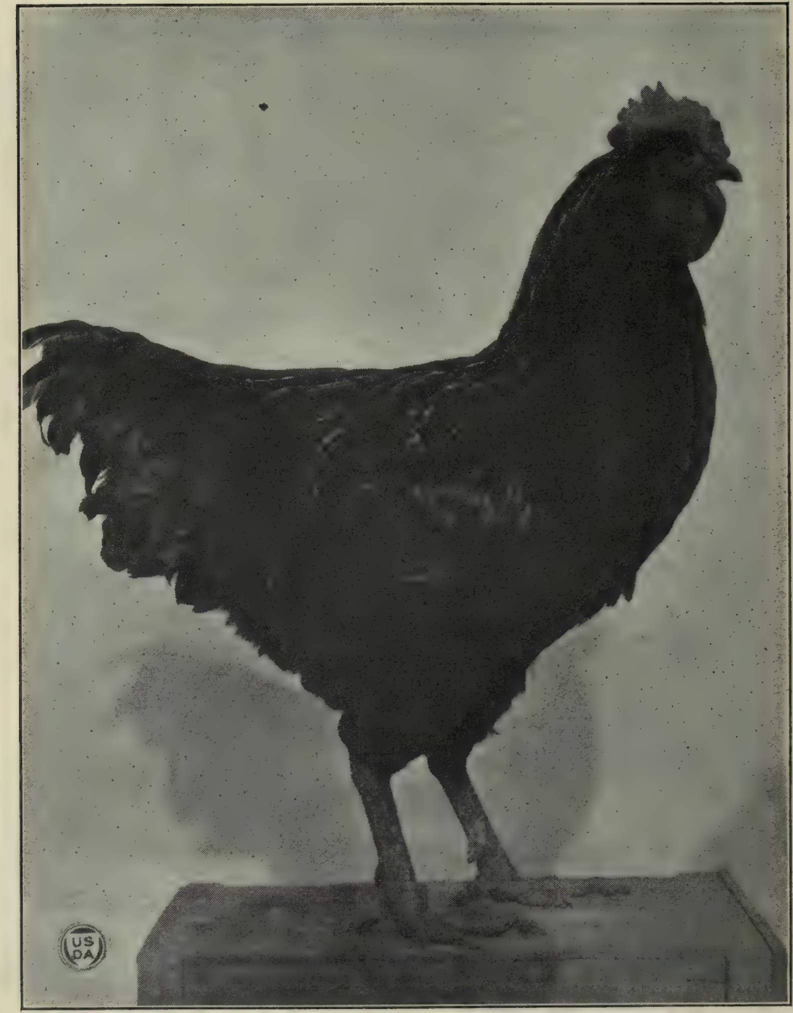

FIG. 14.—Jersey Black Giant, male.

THE JERSEY BLACK GIANT.

The Jersey Black Giant (Figs. 14 and 15), recently admitted to the Standard, is the largest of American breeds. Though usually regarded as meat fowls, they are good layers of brown eggs and resemble the other general-purpose fowls in most of their characters. They are especially good rustlers, considering their size.

This breed originated on the farms of New Jersey, where capons were produced in large numbers for the Philadelphia market. Size and stamina are requisites for stock used for this purpose. The breed was produced as the result of crossing the Black Langshan, Black Java, Dark Brahma, and Partridge Cochin.

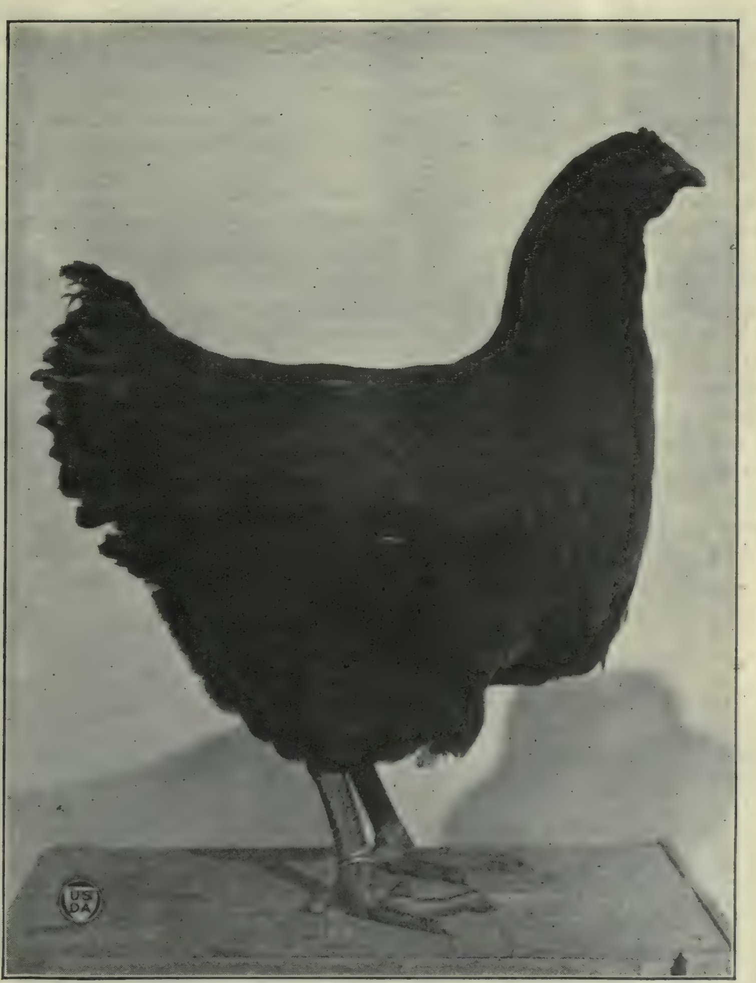

Fig. 15.—Jersey Black Giant, female.

The color of plumage, shanks, and feet and the head points of this bird are similar to those of the Black Java, but the type resembles particularly that of the Plymouth Rock and also approaches that of the Rhode Island Red. The Jersey Black Giant is, however, a much broader, deeper, and longer bird than either of the last two. The plumage in all sections is a rich black with a greenish sheen. The undercolor is lighter, approaching white at the skin. This breed has a single comb and black shanks with yellow on the under surface of the feet and toes.

Standard weights for the breed are: Cock, 13 pounds; hen, 10 pounds; cockerel, 11 pounds; pullet, 8 pounds.

The size and yellow skin make the Jersey Black Giant a very attractive market fowl except for the objectionable black shanks.

THE CHANTECLER.

The Chantecler, which is a recent addition to the Standard, originated in Canada, and is especially adapted to extreme northern sections because of its small comb and wattles and its heavy, closely feathered plumage, which enable it to withstand cold weather. The comb and wattles, on account of their small size, are not likely to become frozen.

The most noticeable characteristics of the breed are a conformation resembling that of the Cornish, especially in breast development and carriage, and the smallness of the cushion-shaped comb and the wattles. The Cornish, White Leghorn, White Wyandotte, Rhode Island Red, and White Plymouth Rock were used in producing the new breed. This stock has produced a general-purpose breed showing greater length of body than the Cornish and having better egg production than is usually found in that breed. The yellow skin and shanks, combined with good size, make the Chantecler attractive as a market fowl. The breed produces a brown egg, the same as the other general-purpose breeds of the American class.

The standard weights are: Cock, 9 pounds; hen, 7 pounds; cockerel, 7 pounds; pullet, 6½ pounds.

WASHINGTON : GOVERNMENT PRINTING OFFICE : 1923

U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1348

The CORRUGATION METHOD OF IRRIGATION

THE CORRUGATION METHOD of irrigation is well adapted for the efficient application of water to steep or irregular slopes, or where the farmer is required to use a small stream of water, or for new land which has not yet been thoroughly prepared for irrigation. It may sometimes be used to advantage in conjunction with the border method of irrigation as a means of spreading the water evenly over the border strip. This bulletin describes the most approved practices to be followed when the corrugation method is employed and points out its advantages and limitations.

Washington, D. C. **Issued August, 1923**

THE CORRUGATION METHOD OF IRRIGATION.

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INTRODUCTION.

The corrugation method of irrigation is a modification of the older and more widely known furrow method. It had its origin in the Northwestern States and is now generally used there in watering uncultivated crops such as small grains and hay. Some means of flooding the entire ground surface is usually employed elsewhere for the irrigation of such crops; but owing to the rough topography, peculiarities of soil, methods of planting and harvesting crops, and the established practice of using small streams of water for irrigating, the corrugation method has come into general favor in the Northwest.

The principle involved in the corrugation method is that of subirrigation accomplished by allowing small streams of water to flow through a series of narrow, shallow furrows or corrugations long enough to permit the horizontal seepage from adjacent irrigated corrugations to meet, thus resulting in a thorough wetting of the soil between the corrugations. Four general features of the method should be considered in planning for irrigation by means of corrugations, these being the field ditches, the structures, the corrugations themselves, and the wasteways.

FIELD DITCHES.

Field ditches are the portion of an irrigation canal system which supplies water to a single farm unit or field and for which the individual farmer is responsible. The term includes the farm supply ditch and head ditches, the latter being that part of the system from which water is turned on the land.

Owing to the limited head of water used, these field ditches are small and easily constructed. The general practice calls for the continuous use of from one one-hundredth to one-fiftieth cubic foot per second of water per acre of land irrigated during an irrigation season, which results in the use of a stream which rarely exceeds 2 cubic feet per second and averages considerably less. Such ditches are usually made by plowing and removing the loose dirt from the furrow with an ordinary "A" ditcher. This operation repeated several times, supplemented by a little handwork, completes the ditch.

Table 1 gives the different carrying capacities of two small ditches on various slopes. These ditches are of a size close enough to that ordinarily required to serve as a guide in the design of such ditches.

TABLE 1.—*Carrying capacities of field ditches.*

DITCHES 5 INCHES DEEP, 14 INCHES IN BOTTOM WIDTH, WITH 1½ TO 1 SIDE SLOPES, ON DIFFERENT GRADES.

Grade.			Mean velocity.	Carrying capacity.		
				Cubic feet per second.	Miners inches.	
					6-inch head.	4-inch head.
Inches per rod.	*Feet per 100 feet.*	*Feet per mile.*	*Feet per second.*			
¼	0.126	6.67	0.71	0.53	21	26
½	.252	13.33	1.01	.76	30	38
¾	.379	20.00	1.24	.93	37	47
1	.505	26.67	1.43	1.08	43	53
1¼	.631	33.34	1.60	1.20	48	60
1½	.758	40.00	1.76	1.32	53	66
1¾	.884	46.67	1.91	1.43	57	71
2	1.010	53.33	2.06	1.53	61	77
2½	1.263	66.67	2.29	1.71	68	85
DITCHES 6 INCHES DEEP, 16 INCHES IN BOTTOM WIDTH, WITH 1½ TO 1 SIDE SLOPES, ON DIFFERENT GRADES.						
¼	0.126	6.67	0.80	0.85	34	42
½	.252	13.33	1.17	1.22	49	61
¾	.379	20.00	1.41	1.50	60	75
1	.505	26.67	1.67	1.74	70	87
1¼	.631	33.34	1.87	1.95	78	98
1½	.758	40.00	2.05	2.13	85	106
1¾	.884	46.67	2.21	2.30	92	115
2	1.010	53.33	2.37	2.47	99	124
2½	1.263	66.67	2.66	2.77	111	139

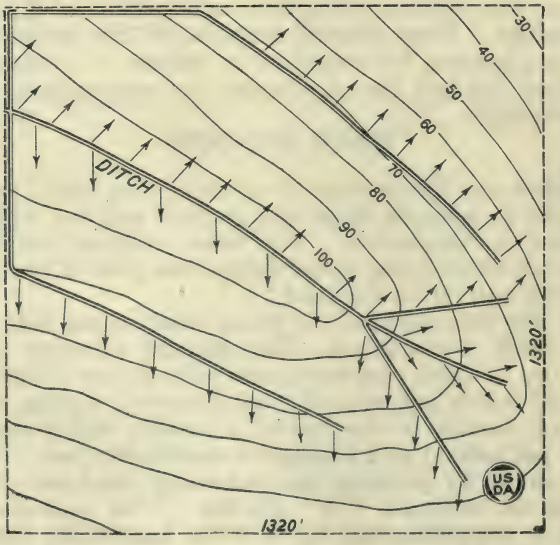

FIG. 1.—Characteristic field map showing location of contours and ditches.

Where the slope of the land is uniform and in one direction, the ditch system is quite simple. A supply ditch is run directly down the steepest slope and head ditches are located at right angles to it, or nearly so, on grades of from 0.05 to 0.25 per cent and at intervals of from 150 to 600 feet, depending upon the length of corrugation to be used.

Where the ground surface is uneven in character there is no general plan that will fit all conditions for laying out a system of farm ditches, but the water must be released at points on a field from which it may flow directly down the steepest slope, or nearly so, a requirement of the corrugation method which will be explained later. As long as this requirement is satisfied the grade need not be uniform, though a uniform slope between head ditches is to be preferred. A contour map upon which trial locations can be made will assist greatly in laying out a satisfactory system of field ditches. The elevations of a number of points must be determined to permit the preparation of an accurate map of surface conditions. Especially where land is uneven this task is best left to a surveyor. Two typical irrigation systems are illustrated in Figures 1 and 2.

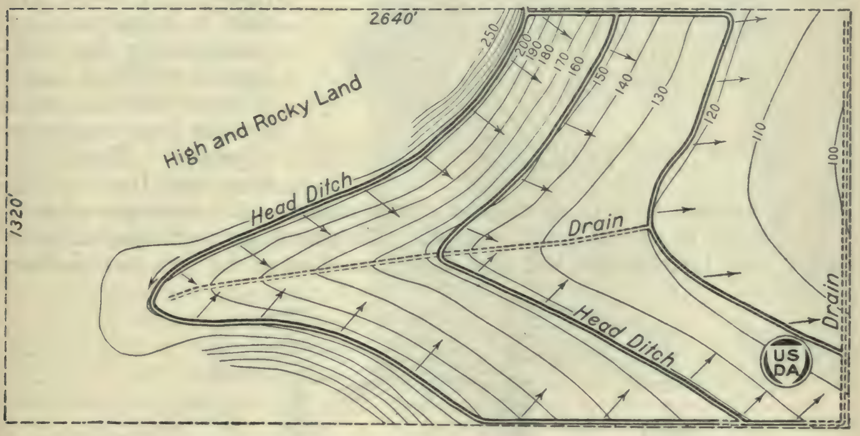

FIG. 2.—Field laid out with ditches on contours.

What has been said of the location of a system of field ditches for the corrugation method applies as well to a pipe-line distribution[1] system. However, because of their initial cost, such installations are usually limited to the irrigation of orchards and other highly profitable crops and can seldom be afforded for hay, small grains, and other crops raised under the corrugation method.

STRUCTURES.

Considering field ditches in the order of their usual construction and operation, the point of division, diversion, and measurement of water from larger streams should first receive attention. At this point water is usually admitted to a number of farm ditches through several head gates which are so regulated as to show the proper depth of water over a weir[2] located some distance below the gate. A standard head gate in general use in southern Idaho is shown in Figure 3. An accurate method of measuring water where streams diverted to farm ditches are so numerous and so small is very desirable, since it promotes a careful use of water and tends to reduce disputes and dissatisfaction regarding the quantity of water delivered. Under many canal systems no attempt is made to do more than divide the total quantity of water available among a number of users, and this is done only approximately by varying the width of outlet directly with the size of stream supposed to be diverted. The structure used for this purpose is known as a proportional division box. An example of such a structure is shown in Figure 4. Although proportional division boxes can be constructed and maintained so as to give satisfactory results, the fact is that they are not usually constructed and maintained with sufficient care and there is little to recommend their use.

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[1] U. S. Dept. of Agr., Dept. Bul. 906, The Use of Concrete Pipe in Irrigation.

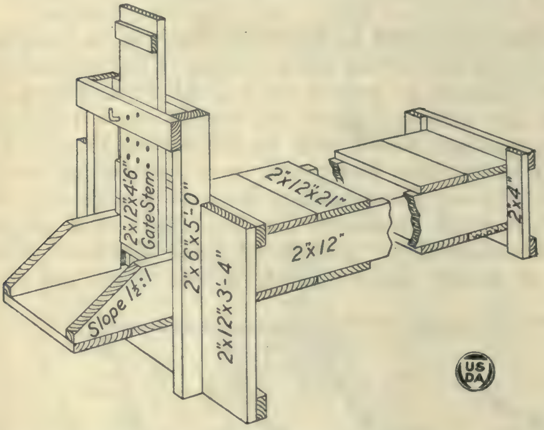

Fig. 3.—Standard wooden headgate used for delivery of small irrigating streams.

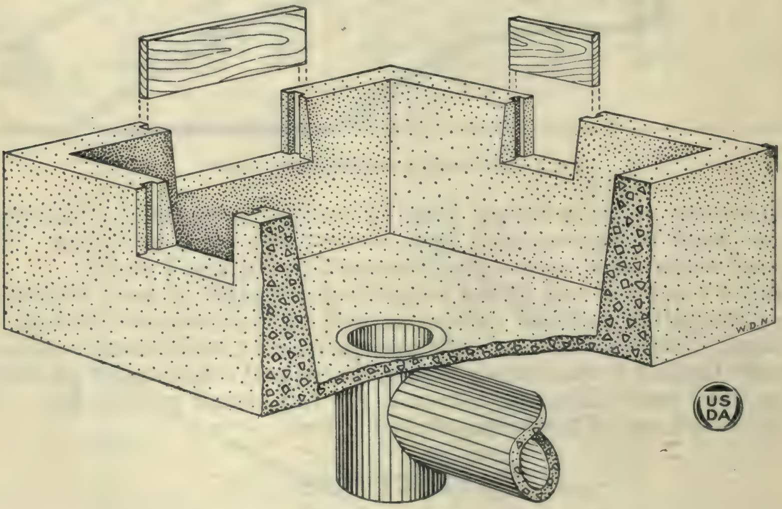

Fig. 4.—Proportional division box.

When it is necessary to locate a ditch where the grade will be so steep as to cause erosion of an earthen channel miniature chutes are used. To form these the ditch may be lined with concrete, but a wooden V-shaped trough made up of short planks laid one into the other on the ground, as illustrated in Figure 5, meets this requirement very successfully. Such an arrangement is not expensive and has the added advantage that it may be removed easily during farm operations, thus reducing the area of waste land.

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[2] See U. S. Dept. of Agr., Farmer's Bulletin No. 813, Construction and Use of Farm Weirs.

In the irrigation of rolling, uneven land, the small farm flume is a necessary structure. It may be a home made rectangular affair built preferably of redwood, or it may be of the semicircular metal type which can be purchased. Flumes of either type are satisfactory if properly installed, but the homemade wooden flume is often carelessly built and poorly maintained and it then constitutes a weakness in the farm ditch system as well as a

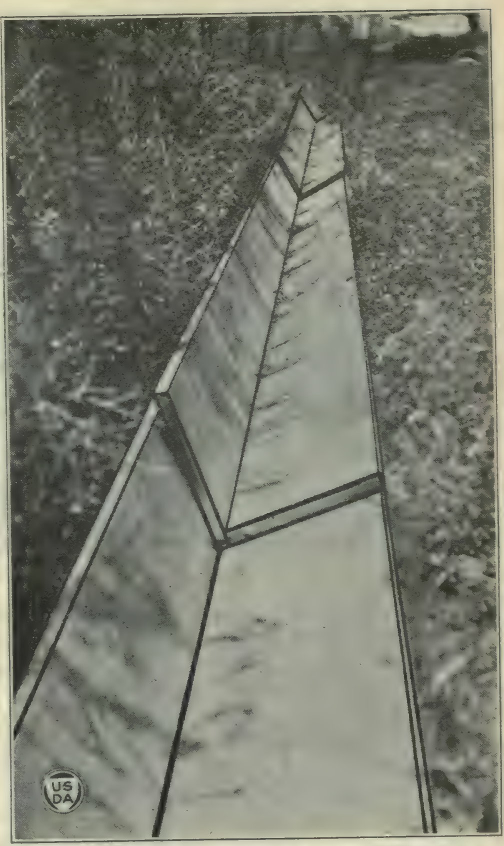
FIG. 5.—Wooden trough used to prevent soil erosion.

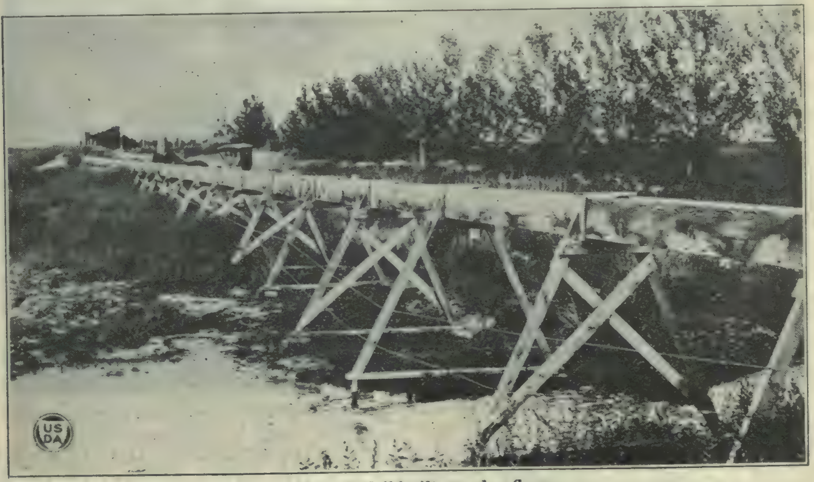
FIG. 6.—Well built wooden flume.

source of water waste. A substantially built and well-maintained wooden flume is shown in Figure 6; Figure 7 shows one in bad condition. Metal flumes are seldom so poorly constructed and cared for. A good semicircular flume is shown in Figure 8. It will be found that frequent treatment of both metal and wooden flumes with a heavy asphaltic waterproof paint will add greatly to their life.

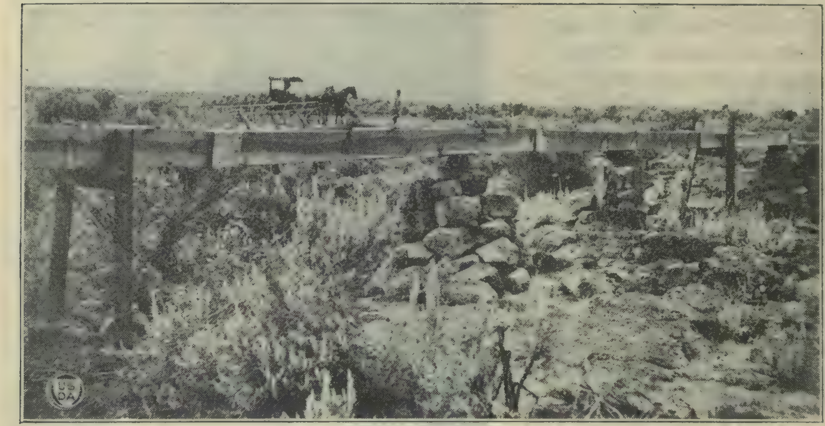

FIG. 7.—Poorly built wooden flume.

Tables 2 and 3 give the maximum carrying capacities of various sizes of small wooden and metal flumes laid on different slopes.

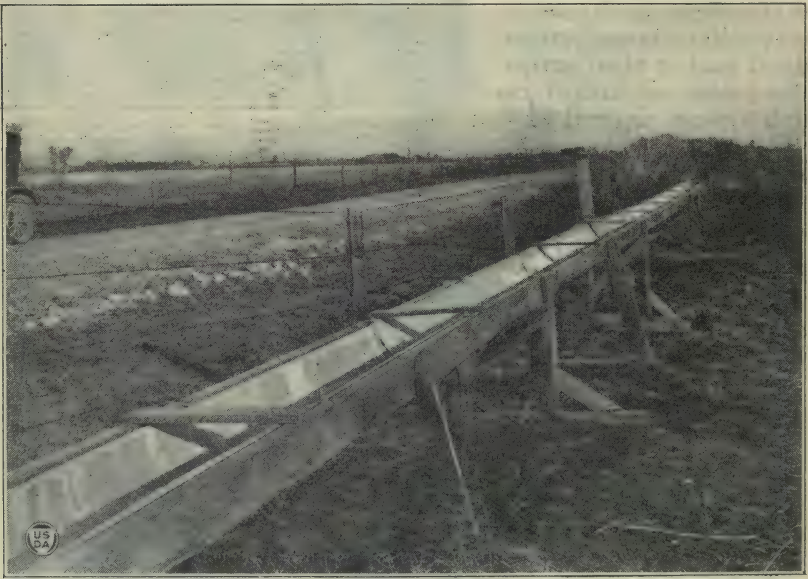

FIG. 8.—Small semi-circular metal flume.

Permanent structures of wood or concrete, similar to that shown in Figure 9, may be used for diverting the irrigation stream from the main supply ditch to head ditches. However, a movable canvas (Fig. 10) or metal dam (Fig. 11) is usually all that is necessary.

TABLE 2.—*Carrying capacities of small rectangular wooden flumes on different slopes when running full.*

Inside measurement.	Discharge.	Fall, in feet per 100 feet.								
		0.05	0.10	0.15	0.20	0.30	0.40	0.50	0.60	0.80
Inches.										
	Cubic feet per second	.29	.41	.51	.60	.73	.85	.95	1.04	1.20
7 by 8	Miner's inches, $\frac{1}{40}$ second-foot	11.6	16.4	20.4	24.0	29.2	34.0	38.0	41.6	48.0
	Miner's inches, $\frac{1}{50}$ second-foot	14.5	20.5	25.5	30.0	36.5	42.5	47.5	52.0	60.0
	Cubic feet per second	.56	.81	.99	1.15	1.41	1.64	1.83	2.01	......
9 by 10	Miner's inches $\frac{1}{40}$ second-foot	22.4	32.4	39.6	46.0	56.4	65.6	73.2	80.4	......
	Miner's inches $\frac{1}{50}$ second-foot	28.0	40.5	49.5	57.5	70.5	82.0	91.5	100.5	......
	Cubic feet per second	.95	1.36	1.68	1.95	......	......	......	......	......
11 by 12	Miner's inches $\frac{1}{40}$ second-foot	40.0	54.4	67.2	78.0	......	......	......	......	......
	Miner's inches $\frac{1}{50}$ second-foot	47.5	68.0	84.0	97.5	......	......	......	......	......

TABLE 3.—*Carrying capacities of small semicircular metal flumes on different slopes when running full.*

Inside diameter.	Discharge.	Fall, in feet per 100 feet.							
		0.05	0.10	0.15	0.20	0.30	0.40	0.50	0.60
Inches.									
	Cubic feet per second	.13	.19	.23	.26	.33	.38	.43	.47
7⅝	Miner's inches, $\frac{1}{40}$ second-foot	5.2	7.6	9.2	10.4	13.2	15.2	17.2	18.8
	Miner's inches, $\frac{1}{50}$ second-foot	6.5	9.5	11.5	13.0	16.5	19.0	21.5	23.5
	Cubic feet per second	.24	.34	.42	.49	.60	.71	......	......
9½	Miner's inches, $\frac{1}{40}$ second-foot	9.6	13.6	16.8	19.6	24.0	28.4	......	......
	Miner's inches, $\frac{1}{50}$ second-foot	12.0	17.0	21.0	24.5	30.0	35.5	......	......
	Cubic feet per second	.40	.58	.72	.84	1.02	......	......	......
11½	Miner's inches, $\frac{1}{40}$ second-foot	16.0	23.2	28.8	33.6	40.8	......	......	......
	Miner's inches, $\frac{1}{50}$ second-foot	20.0	29.0	36.0	42.0	51.0	......	......	......
	Cubic feet per second	.60	.86	1.06	1.23	......	......	......	......
13¼	Miner's inches, $\frac{1}{40}$ second-foot	24.0	34.4	42.4	49.2	......	......	......	......
	Miner's inches, $\frac{1}{50}$ second-foot	30.0	43.0	53.0	61.5	......	......	......	......
	Cubic feet per second	1.19	1.70	......	......	......	......	......	......
17	Miner's inches, $\frac{1}{40}$ second-foot	47.6	68.0	......	......	......	......	......	......
	Miner's inches, $\frac{1}{50}$ second-foot	59.5	85.0	......	......	......	......	......	......

Probably the most important structures and those which are used more exclusively under the corrugation method of irrigation are to be found in the head ditch, where they are employed as a means of distributing a stream of water evenly among a number of corrugations. Structures such as checks, outlet and overflow boxes, and wooden spouts, and the head ditch itself must be capable, increasingly with the steepness of slope and looseness of soil, of delicate adjustment, so that irrigating streams in all corrugations may be regulated to deliver the proper amount during any absence of the irrigator. The system must be safeguarded to prevent the overflow or washing through of ditch banks which would result in the release of such streams as would damage fields and crops by flooding or erosion.

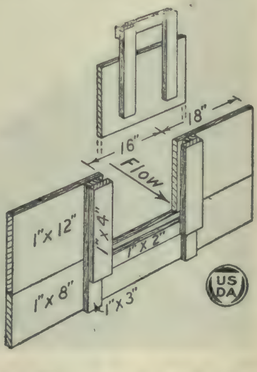

FIG. 9.—Permanent wooden check for use in small capacity field ditches.

Usually water is not allowed to flow directly into corrugations from the head ditch, but first enters distributing basins by outlets through the sides of the ditch. These distributing basins are long, narrow depressions about 2 feet wide at the water line and vary in length from 20 to 60 feet, depending upon the head of water available and the slope of the field alongside the ditch. Unlike the ditch itself, the basin must be level, and a series of basins has the appearance of low, broad steps up the slope of a field. They must be so built as to permit the discharge of water to the field throughout the length of each basin. These basins are divided from each other by earthen dams, forming a series of small reservoirs, each of which has as its upper bank the lower side of the head ditch. The purpose of these distributing basins is to permit the regulation of a number of small streams as a unit and to allow a division of the main irrigating stream to be made among several basins, so that damage to field and crop may be reduced in case of a break in the banks of the distribution system. The use of the distributing basin is a wise precaution in the irrigation of new lands or loose soil or steep slopes; it is also of assistance in the equal division of water among a number of corrugations. The arrangement of head ditch and distributing basin is shown in Figure 12.

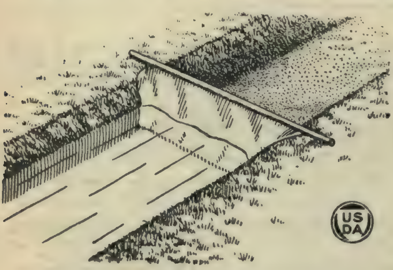

FIG. 10.—Portable canvas dam in ditch.

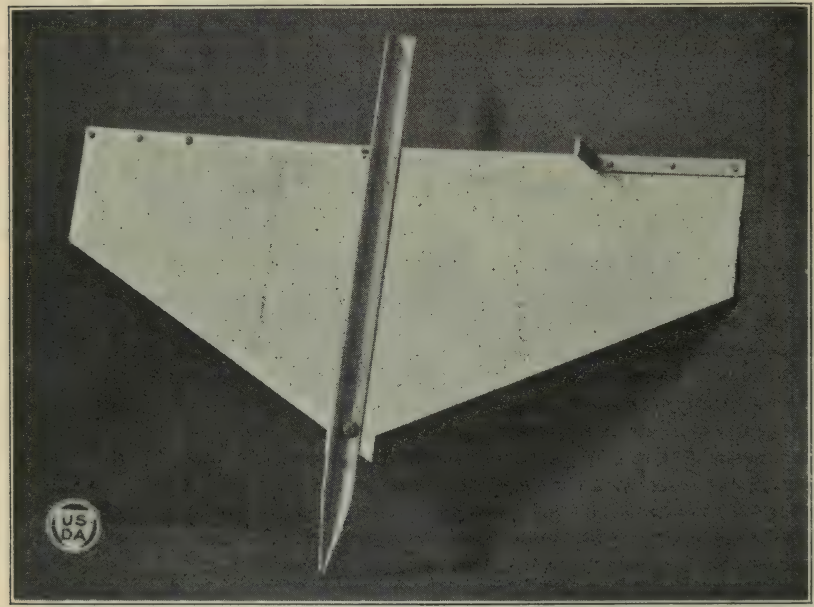

FIG. 11.—Portable metal dam.

Frequently, as a field becomes well set with alfalfa or other perennial crop, features of the corrugation method of irrigation having the purpose of controlling and regulating streams for each corrugation are discarded and the distribution of water comes to resemble that of the ordinary flooding method. Continuous care should be taken, however, to see that the proper streams are used to economize in the use of water as well as to minimize the early danger of washing the field.

The outlet from the head ditch to a distributing basin is usually a redwood box about 3 feet long and from 4 to 8 inches square. A shingle over the outer end or a slide or pivoted gate usually serves to close, or partly close, the opening. At the discharge end of the outlet box and against the inside of the outer bank of the distributing basin a wide board should be set to prevent washing away the bank. These outlet boxes are illustrated in Figures 12 and 13.

The flow of water from the head ditch to distributing basins may be controlled by regulation of the water level in the head ditch, which is accomplished by means of checks. These structures may be made of wood or concrete (Fig. 14) or may be merely canvas dams. Besides providing a means for proper adjustment of the flow to each distributing basin, the check automatically takes care of any increased flow which might occur in the head ditch by allowing excess water to pass over its crest.

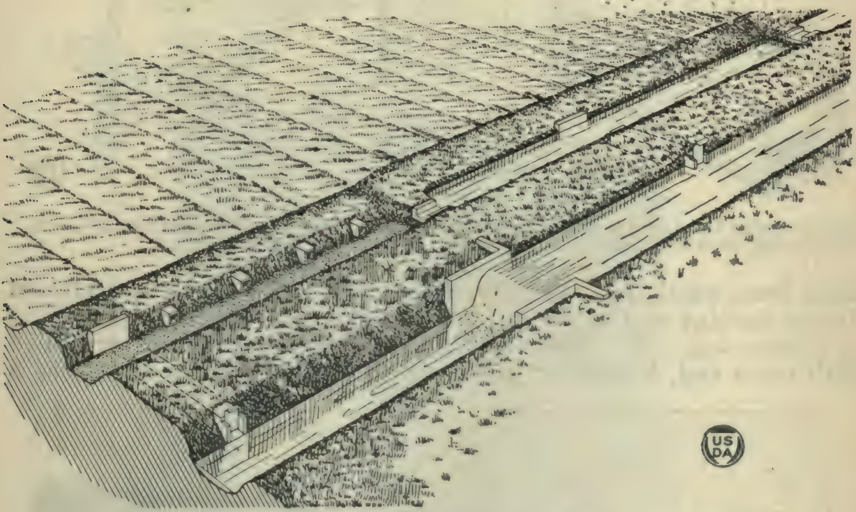

FIG. 12.—Arrangement of head ditch and distributing basin for corrugation method.

At intervals, depending upon the spacing of corrugations, provision is made to allow small streams of water to feed from distributing basins to corrugations. These streams vary from one-fifth to 1 miner's inch, depending upon the size which may be used safely without washing or flooding the soil. Where the soil is heavy enough to withstand washing at these outlets, distribution is accomplished merely by grooving the lower bank deep enough to permit passage of the proper stream of water. Sometimes pieces of burlap are embedded in the grooves, and where very loose soil and steep slopes have to be dealt with coarse manure or fine straw is mixed with the earth, forming the lower bank of the distributing basin. After being thoroughly puddled and packed, this makes a firm bank that will not wash readily. The irrigator usually makes the groove by first denting the bank with his shoe, later shaping it with the blade of a hoe.

One of the chief faults of such a system is the tendency of débris to choke the flow of water through the grooves after the streams have been regulated. Usually the irrigator will regulate a stream during the day and at evening will consider it safe to leave until the next morning. If a storm occurs, the irrigation ditches are filled with trash and, if nothing worse happens, the distribution system is likely to become clogged, causing water to back up in the distributing basins until it breaks through the bank and flows down the field in a stream of sufficient size to cause more or less damage.

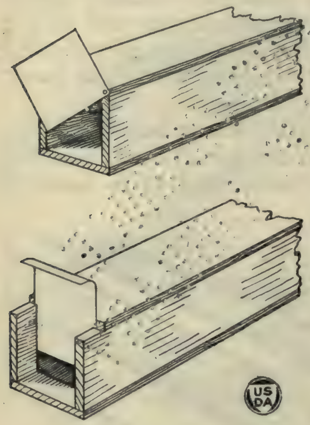

FIG. 13.—Outlet boxes used to connect distributing basins and head ditches.

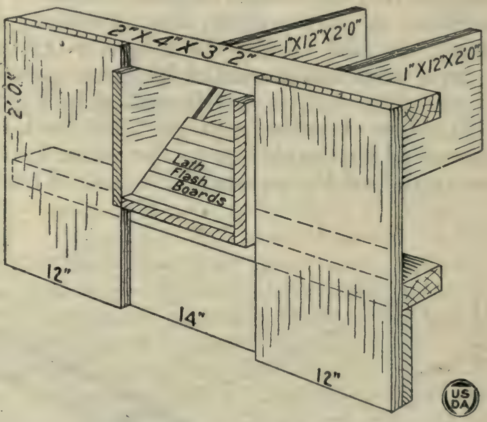

FIG. 14.—Wooden check used to regulate flow of water in head ditch.

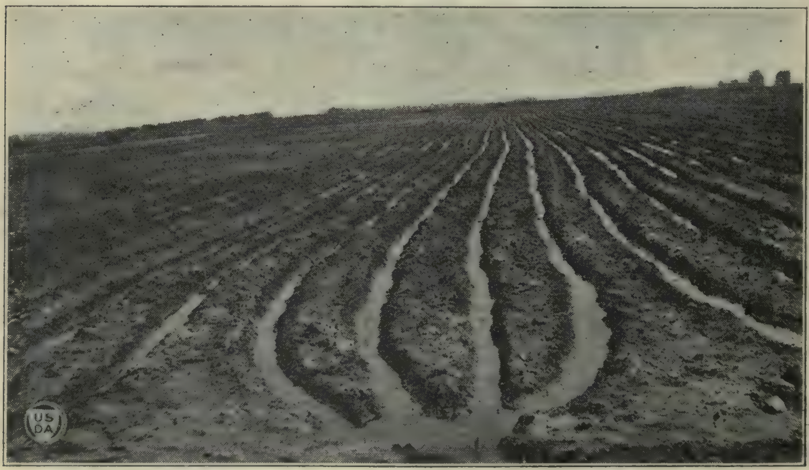

FIG. 15.—Four corrugations supplied from single outlet.

To overcome this danger, a small wooden overflow box (Fig. 12) may be placed in the banks which divide distributing basins so as to allow water to flow from one basin to another after the high-water mark is reached, and finally, if necessary, pass out of the end basin into a waste ditch. Barring accidents due to other causes, such as gopher holes, this will usually eliminate the danger of washing a field, but it does not prevent the waste of water nor the extra labor of readjusting the irrigating streams. Outlets from distributing basins should be, and usually are, made opposite each corrugation. The practice of supplying two or more corrugations from a single outlet, as illustrated in Figure 15, will mean extra work in regulating streams

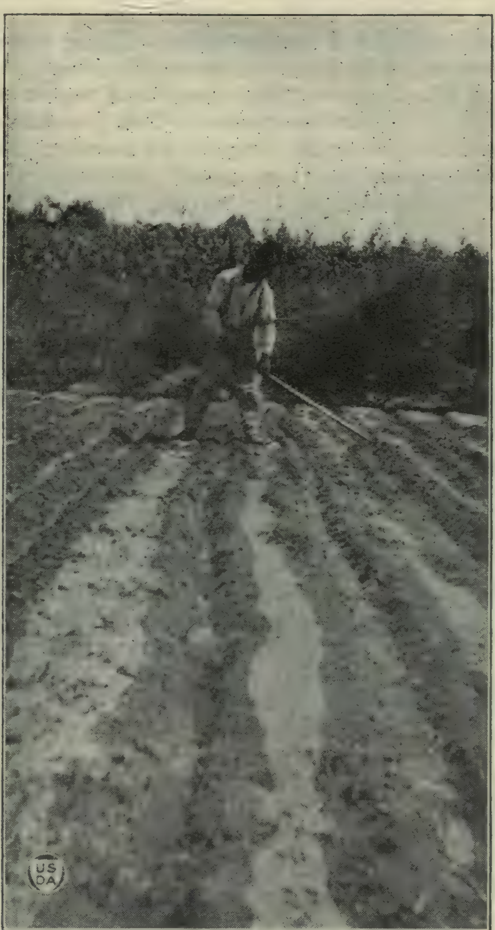

FIG. 16.—Irrigator regulating streams in several corrugations.

and will add to the danger of washing out the lower bank unless outlets are better protected than in the system shown. Figure 16 shows an irrigator regulating streams of water for a number of corrugations, an outlet being provided for each stream of water. This system of distributing water to corrugations is very generally used, is inexpensive, and gives satisfactory results when properly attended to.

Another arrangement for releasing small streams of water is made by embedding wooden spouts at the same level in the lower bank of the distributing basin so that any water entering the basin is divided automatically. These spouts sometimes are made by nailing four laths together; if a smaller opening is required, it is formed by nailing together two strips in each of which a semicircular groove one-half inch in diameter has been cut; or, if a still smaller outlet is wanted, a lath and one of the strips with the half-inch semicircular groove may be nailed together, thus forming an opening half as large as the round one. These spouts are made in lengths of from 2½ to 3 feet. Wooden spouts are much used, especially when ditches are new and fields have been planted for the first time. Their use eliminates most of the annoyance to the irrigator of having floating débris clog outlets, as may happen when grooves are used, and removes the danger of bank erosion, which is always more or less possible where water is allowed to flow over the bank through an earthen channel. On the other hand, this system, as it is usually installed, does not allow a wide variation in the size of the stream used in the corrugations, which is a serious defect in the watering of such crops as alfalfa and clover, where a fairly large stream is required as the crop matures. If large enough spouts are used to water these crops in the first place it will not be necessary to abandon them later. These spouts decay rapidly and consequently need to be replaced frequently. Spouts dipped in hot creosote before being used will last much longer than those not so treated. Figure 17 illustrates the three types of spouts.

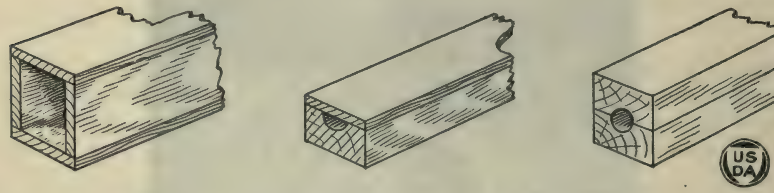

FIG. 17.—Spouts used to release small streams from distributing basins.

Short pieces of rubber hose are sometimes used to siphon the water over the banks of distributing basins, but this method is probably less practical than those already mentioned.

Wooden or concrete troughs, known as head flumes, with small holes bored through sides or bottom or with their sides notched at the proper intervals to discharge water into corrugations, take the place of the head ditch and distributing basins in some systems. These troughs are made either square or V-shaped in cross section. They must be set close to the ground to prevent excessive erosion underneath. A metal slide, or piece of wood or metal pivoted at one end, serves to open and close the outlet. This arrangement is not used so generally as are the first two mentioned, probably on account of its cost of construction and upkeep; however, it permits of proper adjustment and control of irrigation streams and may be said to represent the best practice where the corrugation method is used. A head flume is shown in Figure 18.

CORRUGATIONS.

Corrugations are essentially small furrows spaced from 16 to 48 inches apart depending on the soil type. When carrying the proper stream of water, they are supposed to irrigate the soil thoroughly, principally by a capillary movement of the moisture. Theoretically the stream used in the corrugations is just enough to supply water for uniform absorption on all sides of the corrugation and throughout its length to a depth not greater than the lowest plant rootlets without any waste at the lower end. The length of corrugations and the distance between them should be such as to accomplish this result. Usually the best practice to follow in making corrugations is to have them neither deeper nor wider than is necessary safely to confine the stream. Shallow furrows are most effectual in spreading moisture horizontally at the ground surface. In the irrigation of trees and deep-rooted crops, such as alfalfa, the farmer not infrequently uses deep corrugations with the idea of wetting the subsurface rather than the surface soils, but allows the water to run until moisture shows on the surface. This usually will require a much longer time of application than should be necessary to properly irrigate the crop and will result in a waste of water through deep percolation. Under ordinary conditions corrugations 4 inches deep and 5 or 6 inches wide will be most satisfactory.

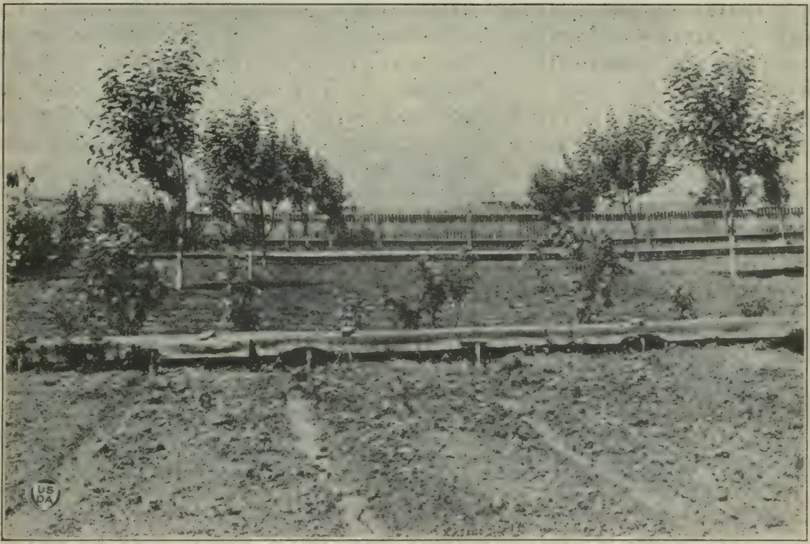

FIG. 18.—Release of water from flume through holes in sides.

The proper distance between corrugations for a particular soil is double the horizontal distance through which moisture will move away from the water line during the time required for the downward moving moisture to reach the maximum depth of plant rootlets. For example, the feeding rootlets of an alfalfa plant extend an average depth of 6 feet into the ground. If the vertical movement of moisture downward is six times as rapid as the horizontal movement, then soil will be moistened for a distance of 1 foot on each side of a corrugation during the time required for wetting the soil to the proper depth. In this case corrugations should be spaced at intervals of 2 feet. Lava ash soils have almost the characteristics of blotting paper, so rapid is the horizontal movement of moisture and so far does the movement extend. In very heavy soils this horizontal seepage is so slow as to render the use of corrugations ineffective as a means of irrigation. In sandy soil the downward movement of moisture is so much greater than the horizontal movement that the loss of water through deep percolation prohibits this method. The presence of hardpan or some other stratum which will halt the downward movement of water is a favorable condition for widely-spaced corrugations. In general practice the interval between corrugations varies from 16 inches to 3 or 4 feet with the most usual spacing about 20 inches.

In determining the spacing, the irrigator often allows labor and expense to have greater weight than the requirements of the soil. The result is that wide intervals between furrows and slow rates of irrigation are used with consequent overirrigation and a probable development of need for drainage. The simple experiment of running water for different lengths of time through separate corrugations and then excavating a trench across them, exposing the area of dampened soil, will aid the irrigator in determining the proper spacing of corrugations and the length of time that water should be allowed to remain in them for any given soil condition. Since the watering, cultivation, and growth of crops very frequently bring about a change in the physical properties of a soil and subsoil, it is advisable to redetermine the proper spacing of corrugations and the proper rate of irrigation after land has been farmed for five or six years.

The length of corrugations varies from 150 to 1,200 feet, but more often they are from 300 to 600 feet. Generally the longer the corrugation, the more inefficient it is in uniformly distributing irrigation water throughout its length, and consequently it should always be as short as practicable. Under ordinary conditions 300 to 400 feet represents good practice, but shorter corrugations are needed for either very steep or comparatively level lands and it may be advantageous to use longer furrows for soil which absorbs water slowly. On very steep slopes an exceedingly small stream is used in order to reduce soil erosion to the minimum and this stream will not travel very far before being absorbed. Under such conditions the length of corrugations is limited to 200 feet or less. Likewise for comparatively level land fields must be short to confine streams to the small furrows and water the land in a reasonable time.

Slopes giving the least difficulty in the operation of the corrugation method are from 1 to 2 feet per 100 feet, but slopes as great as 15 or 20 feet per 100 feet may be irrigated properly by this method. In fact the greatest advantage of the corrugation method is its adaptability to steep, rough land. For comparatively flat land some method of flooding is much to be preferred, but whatever the grade, it is advisable to run the water in the direction of maximum slope, since any appreciable side slope is likely to cause the breaking over of one stream to the next. A field may be terraced to take up the side slope and so provide a more moderate grade, but the expense of terracing, the waste of land, the difficulty of keeping the steep slopes between terraces free from weeds, and the added difficulty of harvesting crops make the use of the original slope preferable.

MAKING THE CORRUGATIONS.

Land is corrugated usually just after the seeding of a crop, a horse-drawn implement capable of making from two to four furrows at one time being used. The steel corrugator (Fig. 19) is a manufactured implement and is particularly useful for recorrugating old alfalfa fields, because it is equipped with a vertical knife and a shoe on the runner which cuts through sod better than the ordinary corrugator. The homemade implement shown in Figure 20 has the advantage that it is not easily clogged with trash, the front portion of the runner pushing aside all material likely to catch on the cutting shoe. Several kinds of corrugators are used, but it will be found that those of the sled type (Figs. 19, 20, and 21) give better results than those mounted on wheels or rollers (Figs. 22 and 23).

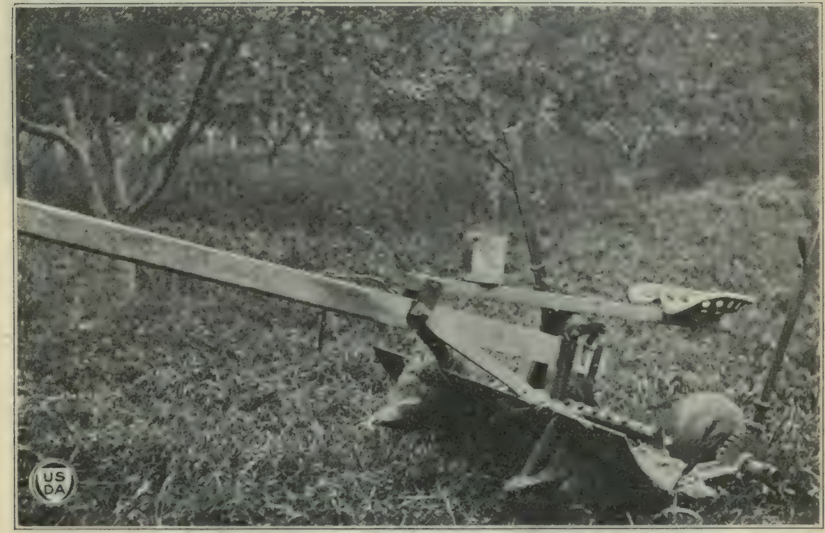

FIG. 19.—Steel corrugator.

The corrugation must be kept open if it is expected to spread water uniformly over a field; if it becomes clogged or damaged so that it will no longer confine the irrigating stream within its banks, the process of irrigation becomes slower and less certain. Such deterioration is caused principally by the use of implements for crop harvesting and the best practice is to recorrugate following each harvest. In the case of pastured fields seeded to grasses, corrugations need cleaning out less often than when wagons and other machinery are drawn over them, but they should not be neglected entirely. Figures 24 and 25 show pastures in which the corrugations have deteriorated.

One man with the proper corrugating implement drawn by four horses can corrugate about 12 acres of land a day.

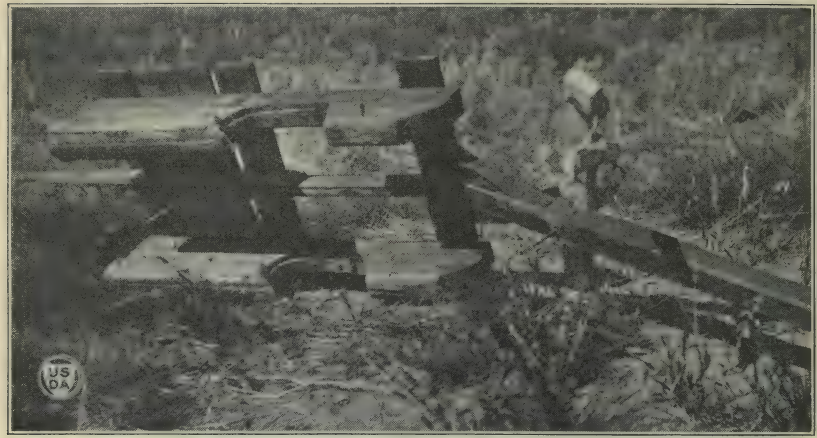

FIG. 20.—Type of homemade wooden corrugator.

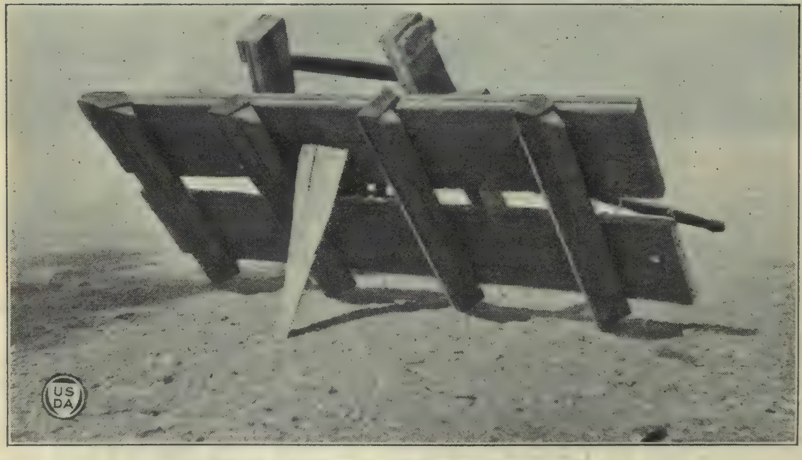

FIG. 21.—Another type of homemade corrugator.

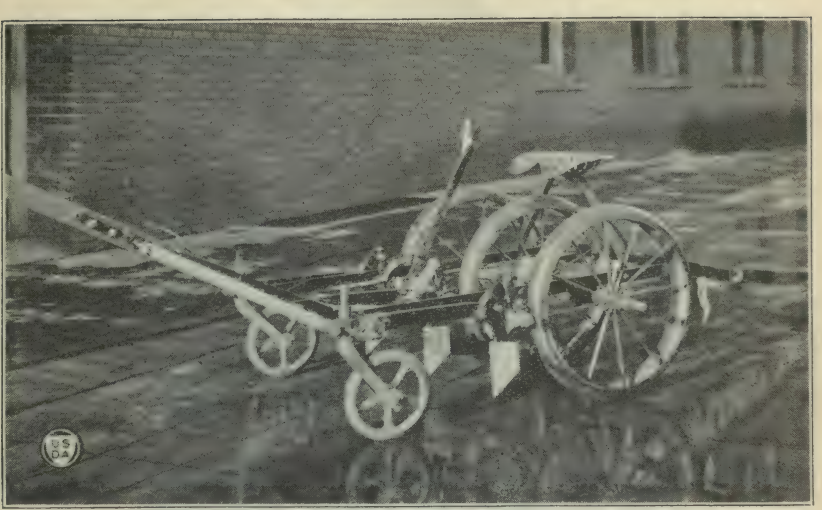

FIG. 22.—Wheel-mounted corrugator.

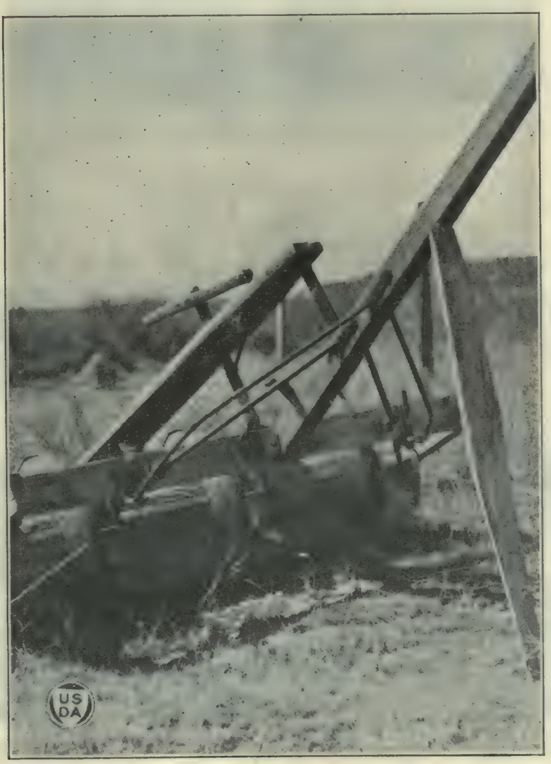

FIG. 23.—Roller corrugator.

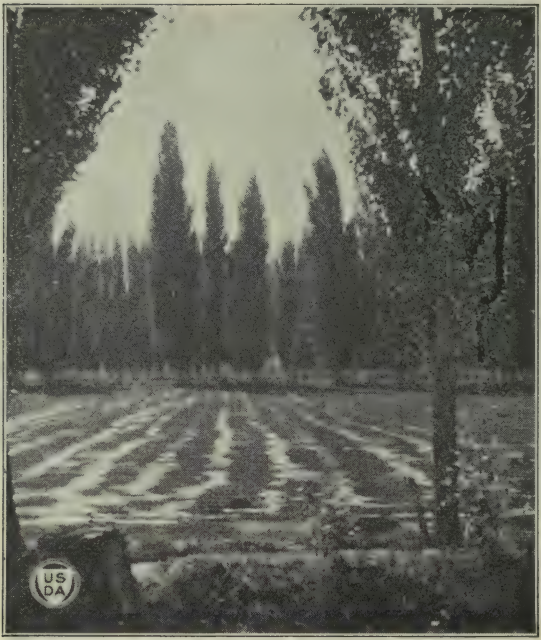

FIG. 24.—Pasture irrigated by the corrugation method. Corrugations slightly deteriorated.

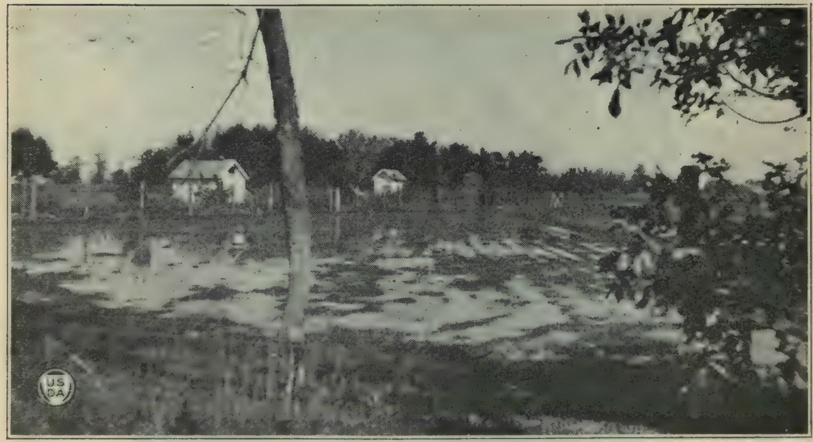

FIG. 25.—Pasture irrigated by corrugations in advanced stage of deterioration.

WASTEWAYS.

Theoretically there should be no surface waste of water where the corrugation method of irrigation is used. As practiced, however, it is most difficult to prevent such waste, and some provision should be always made to use or carry off the excess water. Many fields are so divided as to make possible the collection and reuse of waste water in a series of head ditches located one below the other. In this case the number of corrugations watered should be reduced each time to suit the available head of water. Sometimes the lowest lying field may be converted into a pasture which may be flooded with waste water. Occasionally it is possible to take advantage of a change of grade to slow the irrigation stream at the lower end of the field and thus force more water into the soil and waste less at the end of corrugations.

USE OF WATER IN THE CORRUGATION METHOD.

The adoption of the corrugation method has usually been due to the desire of irrigators to produce maximum crops with the least labor and inconvenience. Considering only the judicious use of water, the method usually could be improved upon. It is impossible to recommend a proper application of this method of irrigation which would suit all conditions, but it is quite within the power of each irrigator to determine for himself the best way to irrigate his land by the simple experiment of using streams of water of different sizes for different lengths of time and then either digging down with a shovel or using a soil auger to ascertain the effect of the irrigation in moistening the soil.

The 24-hour plan is probably the most generally adopted application of the corrugation method. It relieves the irrigator of the somewhat difficult task of regulating and attending to a large number of small streams at night. According to this plan, water is turned into a new set of corrugations in the forenoon and the various streams are adjusted during the day so that they do not erode the soil, overflow the corrugations, or otherwise threaten damage to crop or field. So set, the system is considered safe to be left during the night without further attention. The streams used in the separate corrugations will vary from one-fifth to one miner's inch, the smaller amount being used on newly planted fields or where slopes are steep. The usual regulation of these streams results in considerable run-off at the ends of corrugations, and wasteways or drainage ditches are necessary to carry off the excess water.

This practice is modified in some localities by changing the time during which water is allowed to flow in one set of corrugations. Infrequently the time is reduced to 6 or 12 hours, but more often continuous application for 36, 48, 60, and 72 hour periods is practiced.

Under extraordinary conditions of soil and subsoil this slow rate of irrigation might not result in the use of an excessive amount of water, and if there is no waste, there is no reason why the irrigator should not save himself from the arduous task of night irrigation, but results do not justify this practice generally. The allotment under continuous-flow distribution systems varies from one-half to 1 miner's inch for each acre of land irrigated. It is very doubtful if so small a quantity of water as one-half miner's inch per acre ever is actually used, and it is known that the maximum apportionment often is exceeded. The allowance of 1 miner's inch per acre for a season of 150 days amounts to the acreage use of water nearly 6 feet deep on the land, and since a portion of a farm is usually devoted to a part-season crop, the acreage irrigated throughout the entire season may actually receive more than the depth of water indicated by the acre allotment. The depth of water actually applied in the corrugation method will usually fall between 4 and 10 feet. Under general agricultural conditions throughout the Northwestern States the depth of water which should be applied to meet plant requirements is much less than this.

UTILITY OF THE CORRUGATION METHOD.

The corrugation method should not be classed with the regular furrow or the border methods so far as general desirability in effecting the application of water to crops is concerned. However, there are conditions which justify its adoption and make it a commendable method of irrigation. It offers a way to irrigate uncultivated crops with streams which would ordinarily be too small for practical use. The continuous-flow system of delivery, wasteful of water and time as it is, has become established throughout the Northwestern States, and its conversion into the more desirable rotation plan, which adapts the irrigation head to conditions of soil, crop, and grade will be a slow process if accomplished at all. Thus in the Northwest there is many a small farm where the irrigator must use, as best he may, a stream varying from 10 to 20 miner's inches of water, and the corrugation method offers the most satisfactory way of applying these small streams of water to crops.

Probably the greatest advantage of the corrugation method is its adaptability to watering very steep slopes. Such land might also be terraced, so providing a grade which would permit the practice of flooding, but as stated before this is not desirable and is often impossible because of the limited depth of good soil. The maximum slope which might safely be flooded during all crop stages is 1 foot in a horizontal distance of 100 feet, and where an old stand of heavy alfalfa or similar growth is present this slope might be two or three times as great, depending somewhat upon the soil. The corrugation method, on the other hand, may be used with a minimum preparation of the land where the fall is as great as 15 or 20 feet in a horizontal distance of 100 feet. A good rule to follow is to use the border method instead of the corrugation method wherever possible. In many instances the latter may be employed where the land is too steep for the use of the border method on freshly cultivated land and later may be converted into the border method, thus ultimately making use of a more economical method of irrigation. The corrugation method, though not the best way to irrigate flat land, may be used to advantage in connection with the border method in the watering of such land with small heads of water. The corrugations in this case serve the dual purpose of keeping the water spread out over the area between borders and leading it along the lands. In the event that the two methods are to be utilized, fields should be prepared for border irrigation[3] before a crop is planted. This adaptability of the corrugation method to steep slopes has resulted in the reclamation of some of the most valuable land in the Northwest and besides has been a factor in eliminating unsightly and undesirable waste land within an irrigation project.

The minimum expense and work attached to the preparation of land and the installation of the corrugation method has proved to be of great assistance to the new settler of the Northwest in that it has allowed him to make the business of reclaiming land pay from the very start. The expense and delay usually necessary for leveling and otherwise preparing land for irrigation is largely eliminated. Clearing away the brush and preparing of a seed bed is usually all the attention new land receives before a crop is planted. Later when the expense may be met easier, undoubtedly it would be advantageous to do some leveling, but as far as general practice goes only a minimum of such work is ever done.

This method of irrigation, although generally resulting in the use of far too much water, permits of a better control of soil moisture at critical times than do any of the methods involving the flooding of the entire ground surface. If the flooding method is used prior to seeding, sufficient moisture must be supplied to germinate the seed and carry the crop to a stage where it will not be injured by the crusting of the ground surface following the next flooding. Failure to meet this requirement is sometimes unavoidable and the result is a loss to the farmer. Not so with the corrugation method. No difficulty need be encountered so far as deficiency of soil moisture is concerned, since water may be applied at any time through corrugations without the disastrous result caused by flooding a newly planted or very young crop, provided water is not kept in the corrugations too long, since in that event the crop will turn yellow and die. Under suitable conditions as to topography and delivery of water, it would seem well to combine this advantage of the corrugation method with the greater economy of the border method. Such a change in method of irrigation would require the special preparation of fields for the border method before a crop is planted.

LIMITATION ON ADAPTABILITY OF CORRUGATION METHOD.

Except under conditions already described where the adoption of the corrugation method is necessary or highly advisable, its use is not warranted, since it generally leads to a practice wasteful of water, time, and labor.

It is wasteful of water because the slow rate of irrigation usually results in moistening the soil deeper than is necessary to meet plant requirements. Sometimes it has been found necessary to abandon the corrugation method in favor of some approved method of flooding the ground surface, because the waste of water proved prohibitive. The slow rate of irrigation, the primary cause of water waste with the corrugation method, is not necessary where crops are flooded because under the latter method the entire ground surface receives moisture through direct contact with the irrigating stream and consequently irrigation may be very rapid with consequent shallow application and negligible loss of water.

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[3] Farmer's Bulletin No. 1243. The Border Method of Irrigation, United States Department of Agriculture.

Where the corrugation method is used, irrigation is a continuous process on each farm throughout the growing season, and the irrigator is never properly relieved of the responsibility of attending to it. Where larger heads of water are used and much more rapid irrigation is practiced, the task is of enough importance to require constant attention, and when finished, as it soon must be for the average farm, water has not been wasted through enforced partial attention, and the irrigator is free to do other work.

The wear and tear on farm machinery and the strain on men and animals in harvesting crops on a corrugated field is another objectionable feature of this method of irrigation. The lack of any systematic method of irrigation on a large number of farms usually may be traced to this objection.

The advantage in the use of the corrugation method for the sprouting of seeds and the furnishing of necessary moisture to young and tender plants, or the necessity of its use for starting crops on steep lands should not justify its use indefinitely when conditions will finally permit the use of an approved method of flooding the ground surface.

The corrugation method is not adapted to washing alkali from the soil, the desired action of carrying the bulk of the salts downward with the water to safe depths below the ground surface being reversed. Horizontal seepage from both sides of the furrows and evaporation on the ridges will result in concentrating more alkali between furrows than is washed downward under the limited area over which water flows. Cultivation of the ground surface might retard this action, but much of the harm is accomplished before the soil is sufficiently dry to work and if the crop is planted the ground surface should not be disturbed. Some method of flooding, not necessarily the border method, should be used to wash down alkali.

Long corrugations and a practice of allowing water to flow for long periods on the same land should be avoided as promoting an extravagant use of water which can be of no extra benefit to crops, but may eventually waterlog the land. The long corrugation also results in uneven distribution of moisture over a field, the upper portion receiving more water than the lower end.

To permit corrugations to clog with sediment and trash until the method has reverted into that of wild flooding is very bad practice. The principle of the corrugation method has faults, but it has advantages that justify its use under conditions described in this bulletin, which is more than may be said of the practice of irrigating by wild flooding with small heads of water.

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U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1349

INCREASING THE POTATO CROP BY SPRAYING

1862 1889

INSECTS AND DISEASES reduce the potato crop of this country each year more than 100,000,000 bushels, according to careful estimates. This loss would be much greater if potato growers did not spray their crops, although spraying is not practiced as widely or as thoroughly as it should be. All growers should endeavor to increase their yield per acre by preventing these losses from insects and diseases.

This bulletin tells how to control the Colorado potato beetle and late-blight (the worst two enemies of the potato), blister beetles, flea-beetles, cutworms and other caterpillars, leafhoppers, aphids or plant-lice, and early-blight and other foliage diseases.

For most of these insects and for the diseases discussed in this bulletin, spraying with Bordeaux mixture and lead arsenate is recommended, but for aphids or plant-lice, contact sprays, such as nicotine sulphate and emulsions, are the best. For blight, Bordeaux mixture is an efficient means of control. Directions for preparing and applying these sprays are given. Other methods of control described in this bulletin, such as jarring and driving, together with crop rotation and clean cultural methods, also help considerably in protecting the crop.

The best spraying outfits available should be procured.

This bulletin is a revision of Farmers' Bulletin 863, which it supersedes.

Washington, D. C. **Issued October, 1923**

INCREASING THE POTATO CROP BY SPRAYING.

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IN THE year 1920 the average yield of potatoes in the United States was estimated at 110 bushels per acre. In the following year the estimated average yield decreased to about 91 bushels per acre. Two of the causes of low crop yield are insects and diseases. It has been estimated that the total loss from potato diseases and insects in the United States frequently is as much as 100,000,000 bushels. In New York in 1912 the potato crop was reduced 20,000,000 bushels as a result of late-blight.

The more important insects and diseases of the potato are discussed in the following pages, with methods of combating them.

THE COLORADO POTATO BEETLE.[1]

Injury by the Colorado potato beetle is the work of both the "slugs" (young, or larvæ) and the beetles, or adults. The beetles, after they pass the winter, appear usually at about the same time as the potato plants, lay their eggs, continue feeding, and frequently destroy unprotected plantings, especially those grown for garden purposes. When the larvæ begin to grow they usually finish the work begun by the beetles, so that in a very short time, or by the time the larvæ are nearly full grown, very little of the potato plants remains except denuded or bare stems and dry and black foliage. After potato fields have become defoliated the beetles and larvæ attack eggplant and other plants of the potato family.

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[1] *Leptinotarsa decemlineata* Say.

Note.—The insects treated in this bulletin are all leaf-feeders. Some of those which feed in the stalks and tubers, viz, the potato stalk-weevil, the common stalk-borer, the potato tuber-moth, white grubs, and wireworms, also are very injurious in certain areas, but these are controlled by methods different from those used against the leaf-feeders, and they will be treated in a separate publication. The diseases treated herein are those affecting the foliage and are preventable, in the main, by spraying. Other potato diseases affecting the tubers or controllable by seed selection are treated in Farmers' Bulletin 1367, Control of Potato-tuber Diseases, and in a forthcoming Farmers' Bulletin on seed-borne diseases of the potato.

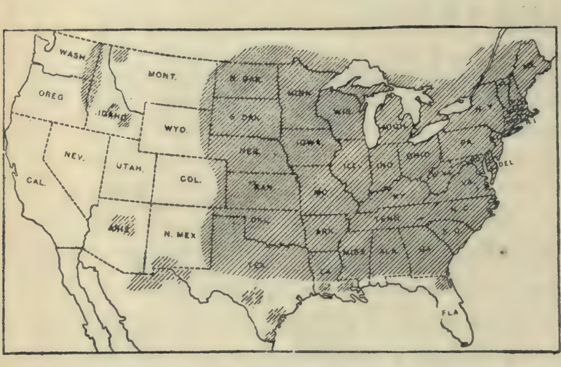

FIG. 1.—Map showing, by shaded areas, approximate distribution of the Colorado potato beetle.

The distribution of the Colorado potato beetle (fig. 1) covers practically the entire United States from the Great Plains eastward to the Atlantic coast, excepting the extreme southern parts of Florida, Alabama, Mississippi, and Louisiana. In Texas it occurs in the tropical region bordering the Gulf of Mexico. It also occurs in more restricted parts of Washington, Oregon, Idaho, Arizona, Montana, Wyoming, Colorado, and New Mexico. In a few of these States it is present, but not as a pest—for example, in some regions of Colorado, where it feeds on a wild plant belonging to the potato family. It is constantly extending its territory as a pest.

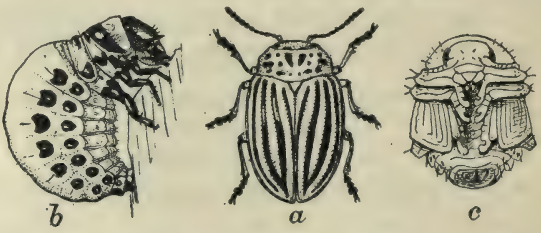

FIG. 2.—Colorado potato beetle: *a*, Beetle; *b*, larva, or "slug"; *c*, pupa. Enlarged.

This potato beetle is well known to all growers of potatoes. The beetle is robust, yellow, and its wing-covers are ornamented with 10 black lines (fig. 2, *a;* fig. 3, *a*). It is three-eighths of an inch long. The "slugs" (young, or larvæ; fig. 2, *b;* fig. 3, *c*, *c*, *d*, *d*) are dark red when first hatched, becoming paler with larger growth. They are slimy, soft in texture, and of disgusting appearance. The pupa, or resting stage, is shown at *c* in Figure 2. The eggs (fig. 3, *b*, *b*) are orange colored and are deposited in masses.

The Colorado potato beetle feeds on practically all plants of the potato family, attacking potato, eggplant, tomato, ground cherry, and Jimson weed, besides other weeds of this family.

In the more northern range of this insect there is probably only one generation a year, or, exceptionally, two generations. Farther southward three more or less complete generations occur. This insect pest passes the winter in the beetle stage, usually from 3 or 4 to 8 or 10 inches underground.

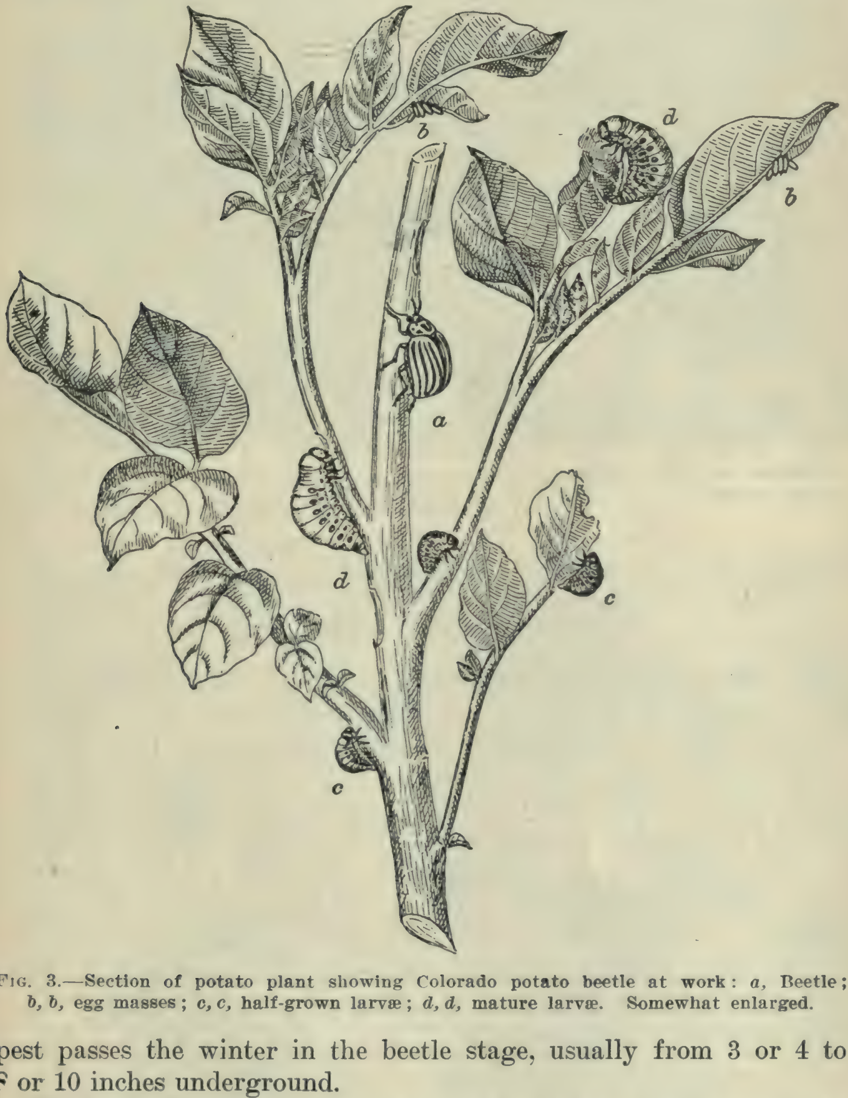

Fig. 3.—Section of potato plant showing Colorado potato beetle at work: *a*, Beetle; *b, b*, egg masses; *c, c*, half-grown larvæ; *d, d*, mature larvæ. Somewhat enlarged.

The beetles appear in the spring, and with the first warm days may be seen in flight. As soon as the female can reach suitable plants after feeding she begins to lay her eggs. A single female is capable of producing between 1,800 and 1,900 eggs. Normally all the eggs hatch, and the entire life cycle from egg to egg may be passed in midsummer in a high temperature in five or six weeks. The possible progeny, therefore, is enormous.

Were it not for the fact that numerous species of insects and higher animals destroy large numbers of the beetles and "slugs" annually, the pest would be much more abundant than it is. (See fig. 4.) In addition to destruction by other insects, of which between 30 and 40 species have been observed actually to prey upon this pest, the bobwhite or quail, robin, crow, and several other birds either pick the beetles from the vines or dig them from the earth, and skunks, snakes, and toads frequently gorge on them. Domestic fowls, especially ducks and guinea fowl, also are of assistance in suppressing this pest.

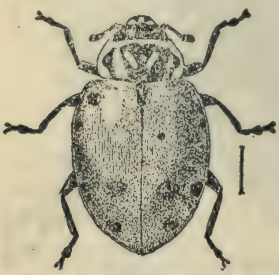

FIG. 4.—A ladybird (*Hippodamia convergens*) which preys on the eggs of the Colorado potato beetle. Much enlarged.

HOW TO CONTROL THE COLORADO POTATO BEETLE.

The Colorado potato beetle may be controlled by proper treatment with certain arsenical sprays. (See figs. 5 and 6.) In the majority of cases, particularly in the Northern States, the combined treatment for diseases and insects outlined on a later page should be followed. The following materials and procedure are advised when this insect alone is to be combated.

ARSENATE OF LEAD.

As a spray for the potato beetle and similar pests, lead arsenate serves the same purpose as Paris green and is even more valuable.

Arsenate of lead has the following advantages over Paris green: (1) It contains less soluble arsenic, which is injurious to the foliage; (2) it is less harmful to young growing plants, and when applied in the proper manner and at the proper strength does not scorch them; (3) it adheres more strongly to the foliage; (4) it is less troublesome to prepare; and (5) it is of greater value than other arsenicals (except zinc arsenite and calcium arsenate) in that it leaves a white coating on the foliage, so that its presence or absence can be determined readily after spraying.

The formula is as follows:

Arsenate of lead (powder)	pound	1
Water or Bordeaux mixture	gallons	25

If the paste form of arsenate of lead is used, 2 pounds to 25 gallons of the liquid is the proper proportion.

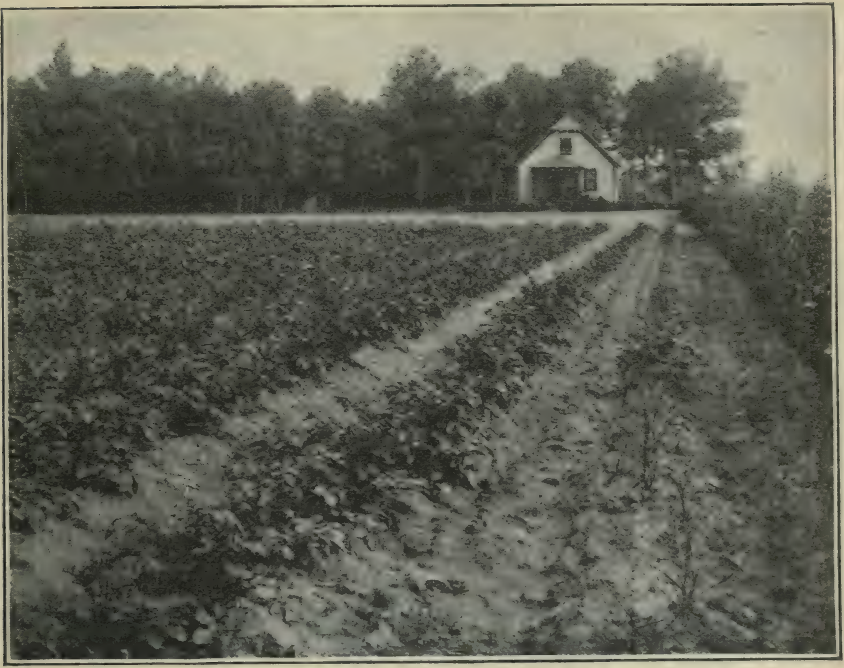

FIG. 5.—Field of potatoes showing outside row unsprayed in comparison with the remainder of the plat sprayed for the Colorado potato beetle with Paris green, one-half pound to 50 gallons of water.

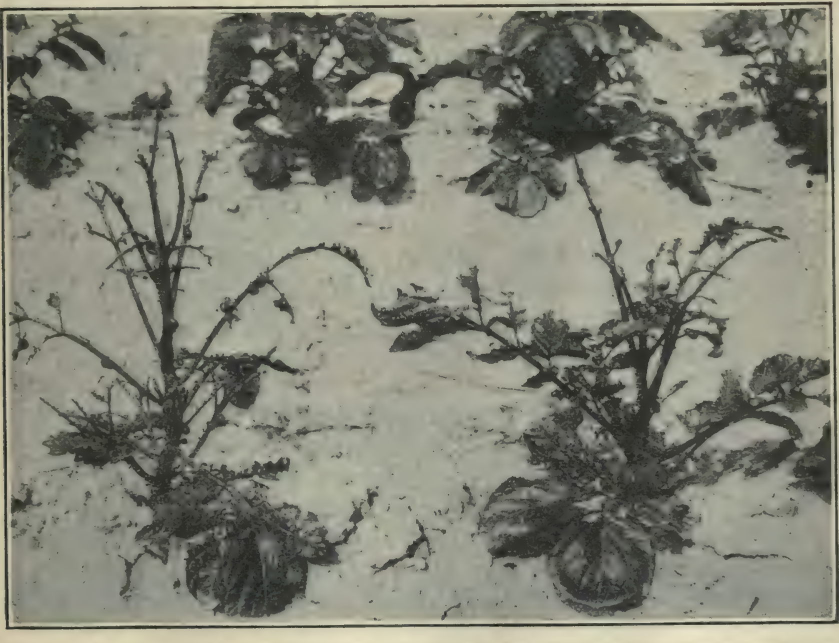

FIG. 6.—In foreground, potato plants not sprayed for the Colorado potato beetle; in background, sprayed potato plants.

For small gardens two-thirds of an ounce, or 10 level teaspoonfuls, of the powder to 1 gallon of water is used.

Two or three sprayings ordinarily will suffice for the spring generation if applied before the eggs are hatched, and about the same number should be employed for the second generation. One or two sprayings for the third generation, when it appears, also should be given.

CALCIUM ARSENATE.

Calcium arsenate, or arsenate of lime, is a valuable remedy for the Colorado potato beetle. Its composition is similar to that of lead arsenate, lime being the base instead of lead. It has a stronger arsenic content than lead arsenate, hence possesses greater killing power and is therefore much cheaper. It is prepared in the same manner for use against vegetable insects. A good quality of powdered calcium arsenate contains 40 to 44 per cent of arsenic oxide and should contain at least 40 per cent, about 1½ per cent of which may be water-soluble. Powdered calcium arsenate, 1 pound, is used in 50 gallons of water or fungicide. For garden use one-half ounce to 1 gallon of water is employed.

Calcium arsenate may be used in combination with other spraying material containing lime or Bordeaux mixture.

As a dust, calcium arsenate is successfully used against certain forms of pests[2] and should be perfectly effective against the Colorado potato beetle, blister beetles, and similar pests. It is best applied thoroughly mixed with from 5 to 10 times its weight of hydrated or air-slaked lime and so proportioned as to apply 3 to 4 pounds of the calcium arsenate to the acre.

A high-grade calcium arsenate 1 part, mixed with dusting sulphur 1 part, and hydrated lime 4 parts, is also satisfactory.

In gardens small dusters are useful. On large patches a knapsack type of bellows duster with a spout attached to a flexible hose is the best machine. The fan type of cotton or tobacco duster gives fair results if the discharge tube is turned sidewise so as to direct the dust into the foliage.

PARIS GREEN.

Although lead arsenate has come into general use against the Colorado potato beetle, Paris green has been for many years a standard insecticide for this pest.

Paris green spray is prepared by mixing the arsenical with water or Bordeaux mixture at the rate of 1 to 2 pounds of poison to 100 gallons of the mixture. When water alone is used quicklime in about the same proportion as the poison should be added to prevent scorch-ing. For the proper mixing and application of this spray a bucket pump or knapsack sprayer of good quality is sufficient for use in small gardens, but on a larger scale a potato sprayer drawn by horses or mules is necessary. A small quantity of water is added to the Paris green to form a thin paste before the bulk of water is added, and the mixture should then be thoroughly blended by churning by means of a force pump or sprayer. The mixture is a mechanical one and the arsenical will soon sink to the bottom. To avoid this it must be stirred constantly while being applied. It is advisable in many cases to apply it in Bordeaux mixture, as this is a valuable insect repellent as well as a standard fungicide and also neutralizes any free arsenic present, thus preventing burning of the foliage.

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[2] Notably the cotton boll weevil and the Mexican bean beetle.

Paris green may also be used dry, mixed with 10 to 20 parts of cheap dry flour, sifted land plaster, or fresh air-slaked lime. This remedy affords best results early in the season on young plants. It should be applied preferably when the dew is on and by means of powder guns or bellows so as to cover the plants and leave as little untreated surface as possible for food for the first-appearing insects.

Precaution to prevent poisoning.—Arsenicals should be labeled properly and the word POISON should appear on the package. It is best to keep poisonous substances under lock and key and where children can not reach them.

Utensils employed in the preparation of arsenate of lead should be cleaned thoroughly after use.

OTHER REMEDIES.

Jarring is of value early in the season. It is performed usually by brushing the beetles and "slugs" into large shallow milk pans or similar receptacles containing a little water on which a thin scum of kerosene is floating. Egg masses should be clipped off whenever observed and destroyed promptly.

Fall and spring plowing, while valuable for most insects which pass the winter in the ground, is less valuable for the potato beetle, because hibernation takes place far under the surface, and very deep plowing would be necessary.

Hand picking is effective early in the season, but later is too slow and laborious.

BLISTER BEETLES.

The potato is subject to injurious attack by blister beetles of several forms. These beetles are slender, comparatively soft bodied, and variously colored. All are general feeders, and a large proportion of them prefer potatoes to other foods. One of the commonest of these is the black blister beetle (fig. 7).[3] It appears at about the time of the flowering of wild aster and goldenrod, and is known also as the "aster bug." Besides potato, it attacks beans, peas, cabbages, and various other plants. Other common species are the margined[4] and the striped[5] blister beetles, shown in Figures 8 and 9. These insects are gregarious and migratory in habit, feeding most voraciously, running rapidly, and flying from time to time. Frequently they descend on a crop and ruin it in a few days, eating both foliage and stems. They appear at different times, according to temperature, usually being most abundant from July to September.

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[3] *Epicauta pennsylvanica* DeG.

CONTROL METHODS FOR BLISTER BEETLES.

Arsenate of lead is the best remedy for blister beetles. It is prepared and applied as directed for the Colorado potato beetle. In addition, in some portions of the West a line of boys and men go slowly through infested fields and drive the beetles ahead of them by short flights or running until they alight or come to rest in windrows of hay, straw, or other dry material, which previously has been prepared along the leeward side of the field. When the beetles take refuge in such a windrow it is burned promptly. This procedure has been followed with success.

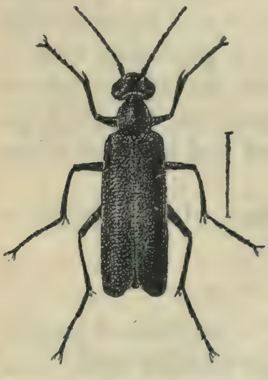

Fig. 7.—Black blister beetle: Adult. Enlarged.

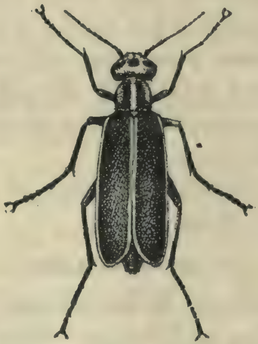

Fig. 8.—Margined blister beetle: Adult. Enlarged.

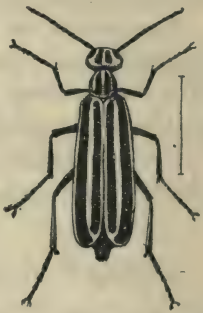

Fig. 9.—Striped blister beetle: Adult. Enlarged.

Prompt application of remedies at the very outset of attack is necessary to save the crop.

FLEA-BEETLES.

The potato is attacked every year by flea-beetles, some of which are specific enemies of the crops of the potato family. Flea-beetles begin their work early in the season. The beetles riddle the leaves of young and tender plants with punctures, causing the leaves to die, thus depleting the vitality of the plant; and the larvæ, or young, feed at and injure the roots. These insects, a little larger than a flea, derive their common name from their small size and from the fact that their powerful hind legs enable them to take long leaps.

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[4] *Epicauta marginata* Fab.

[5] *Epicauta vittata* Fab.

The most important of these insects is the potato flea-beetle[6] (fig. 10). This species occurs practically throughout the potato-growing regions of the country from Canada and New England to the Gulf region and in some districts in California. The most severe injury, however, is done in the North. The larva is the cause of "pimply" potatoes, which bring a lower price in the market, sometimes 5 cents a bushel less than the regular price. Eggplant, tomato, and tobacco also are attacked, and when this insect is numerous it sometimes attacks other plants. Eggs are laid early in May or June, and the life cycle may be completed in midsummer in about 35 days.

During recent years this species has shown a great fondness for tomato, and during the spring and summer of 1917, from April 19 to about the middle of July, injury was widespread. In the case of the tomato, plants were sometimes destroyed by defoliation when potatoes also were present. The aggregate of attack showed injury about equal on these two crops.

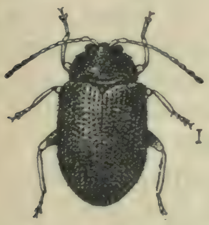

FIG. 10.—**Potato flea-beetle: Adult. Does much injury to young plants. Actual length shown by line at right.**

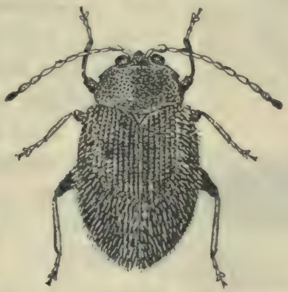

FIG. 11.—**Eggplant flea-beetle, an insect which also attacks potato: Adult. Greatly enlarged.**

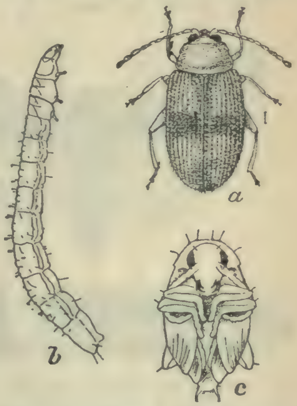

FIG. 12.—**Tobacco flea-beetle, an insect which also attacks potato: *a*, Adult, or beetle; *b*, larva, side view; *c*, pupa, from below.**

The eggplant flea-beetle[7] (fig. 11) and the tobacco flea-beetle[8] (fig. 12) also attack potato, but each is more common on the plant from which its English name is derived.

CONTROL METHODS FOR FLEA-BEETLES ON POTATO.

When potatoes are sprayed with lead arsenate for the Colorado potato beetle or with Bordeaux mixture for diseases, these beetles are repelled to a considerable extent. Because of their active jumping and flying habits they are not likely to remain on the plants during spraying, and are not poisoned to any extent, but they do not attack foliage that has been covered properly with either spray material.

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[6] *Epitrix cucumeris* Harr.

[7] *Epitrix fuscula* Cr.

[8] *Epitrix parvula* Fab.

Although the subject of exhaustive research for many years, a perfectly efficient remedy for the potato flea-beetle has not been found.

All wild plants of the potato family should be pulled up or otherwise destroyed throughout the season in order that the insects may have no other breeding place.

CUTWORMS.

Cutworms frequently do considerable damage to potatoes early in the season and sometimes later. They feed chiefly at night and in the shade, cutting off young plants about even with the ground. A common species is the granulated cutworm.[9] (Fig. 13.)

The best remedy for cutworms is poisoned bait. To mix and apply this bait take a bushel of dry bran, add 1 pound of white arsenic or Paris green, and mix it thoroughly into a mash with 8 gallons of water, into which has been stirred 2 quarts of sorghum or other cheap molasses. This amount is sufficient for the treatment of about 4 or 5 acres of cultivated crops. After the mash has stood for several hours, scatter it, in lumps about the size of a marble, over the fields where the injury is beginning to appear and about the bases of the plants attacked. Apply the bait late in the day, so as to place the poison about the plants before night, which is the time when the cutworms are active. Apply a second time if necessary. If this mash is made up with less water it may be applied with a grain or fertilizer drill to good advantage.[10]

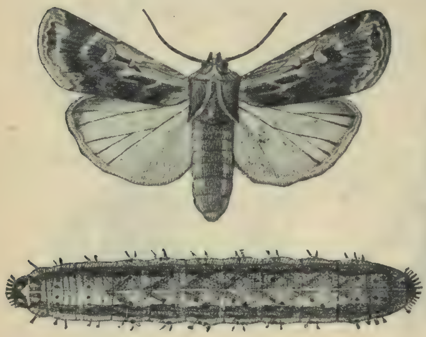

FIG. 13.—Granulated cutworm, an injurious potato insect: Moth above; cutworm, or larva, below. Somewhat enlarged.

Caution.—Arsenicals are deadly poisons and should be handled with great care. Keep children, livestock, and poultry away from this bait.

THE POTATO LEAFHOPPER.[11]

The potato leafhopper (fig. 14), a slender pale-green sucking insect, less than one-eighth inch long, the cause of a disease known as "hopperburn," is one of the worst leafhopper pests. It seriously injures numbers of cultivated plants, the principal ones being potato, beans (on which it also causes "hopperburn"), sugar beet, hemp, apple, raspberry, and cowpea.

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[9] *Feltia annexa* Treit.

[10] Additional information with regard to cutworms may be obtained upon application to the Bureau of Entomology, U. S. Department of Agriculture.

[11] *Empoasca mali* LeB.

Although a native insect of wide distribution, this leafhopper did not attract especial attention until 1914, when it was reported from Pennsylvania and New York as causing a "blight" because of the blighted appearance of the injured leaves. Losses caused to the grower of potatoes from the ravages of this pest, including the accompanying "hopperburn," are reported to be second only to those caused by the Colorado potato beetle. Indeed, in some years when the leafhopper and "hopperburn" abound, the combined loss may even take first rank in certain regions among all potato insects and diseases. The extent of injury fluctuates from year to year, but appears to be greatly on the increase.

The potato leafhopper is generally distributed throughout the United States and occurs in Canada and Mexico. The greatest losses incurred from its attack are in the Northern and Central States, from New York to Montana and southward in Ohio, Illinois, and Kansas.

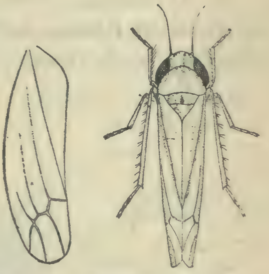

FIG. 14.—Potato leafhopper: At right, adult insect; at left, wing showing venation. Much enlarged.

METHODS FOR CONTROLLING THE POTATO LEAFHOPPER.

The potato leafhopper may be controlled and the "hopperburn" held in abeyance by timely and proper applications of Bordeaux mixture. The potato yield is greatly increased when this spray is employed. Bordeaux mixture, prepared according to the 4–4–50 formula (4 pounds copper sulphate and 4 pounds unslaked lime to 50 gallons of water), has proved a successful combination. Bordeaux mixture *must* be applied to the lower surface of the leaves, and the spraying must be thoroughly done so as to cover practically all foliage. It is also necessary to spray every row of plants from each side. A high pressure, at least 150 pounds, should be maintained in this application in order to cover the leaves with a fine mist, which gives a much better coating than a coarse spray. In abundant leafhopper years at least three applications must be made, the first as soon as the leafhoppers appear on the plants, the second about 10 days or two weeks later, and the third after an equal interval. Sometimes, in very hot, dry summers when leafhoppers occur in vast numbers, a fourth spraying is necessary, applied 10 days or two weeks after the third. The use of Bordeaux mixture on potatoes for the control of certain plant diseases and as a repellent for flea-beetles also acts strongly as a control of this pest.

For further information consult Farmers' Bulletin 1225, The Potato Leafhopper and Its Control.

APHIDS OR PLANT-LICE.

The potato crop suffers great losses during certain seasons, depending largely on atmospheric conditions, from two species of aphids or plant-lice, known, respectively, as the potato aphis[12] and the spinach aphis.[13]

These plant-lice act as disease transmitters, spreading the various types of mosaic disease, leaf-roll, and spindling tuber, by feeding on diseased plants and then migrate to healthy plants, carrying the infection with them. The reduction in yield of potatoes due to the spreading of disease by aphids is much greater than their direct injury by sucking the juices from the plants.

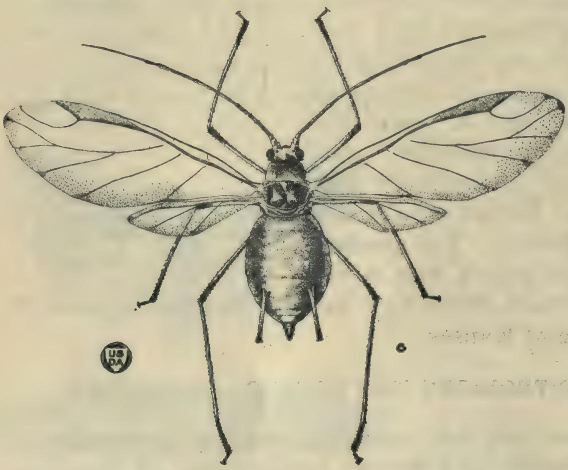

FIG. 15.—Potato aphis: Winged young-producing female. Highly magnified.

The potato aphis (fig. 15) is about as long as the potato leafhopper and is either pink or green, with long delicate wings, and honey tubes — tail-like processes which extend beyond the body. During the growing season it is somewhat closely restricted to potato, tomato, and related plants, but with the harvesting of those crops winged adults migrate to other plants, such as sweet potato and the cucurbits. It is widely distributed, but is more injurious in the northern tier of States.

Nicotine sulphate, a contact insecticide, has been used with success against the potato aphis, in the form of a spray. The standard formula adopted is as follows:

Nicotine sulphate, 40 per cent solution	pint	½
Fish-oil or other soap, dissolved	pounds	2
Water	gallons	50

A spray of nicotine sulphate is for several reasons preferable to kerosene emulsion or soap solutions and is easily prepared. Nicotine sulphate is marketed as a standard solution containing 40 per cent of nicotine, by weight. The soap acts as a "spreader" or

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[12] *Macrosiphum solanifolii* Ashm.

[13] *Myzus persicae* Sulz.

"sticker," and is added to the solution of nicotine sulphate and water. Common bar soap is satisfactory for ordinary purposes. For thorough control this solution should be applied in as fine a spray as possible. Most insects are reached more readily by a mist-like spray, but for sucking insects applications should be made with considerable pressure (150 pounds or more for the larger sprayers or large areas) so that every individual insect may be actually reached or hit by it.

For use in small gardens 1 teaspoonful of nicotine sulphate is used in 1 gallon of water, and to this a 1-inch cube of hard soap is added and the whole thoroughly mixed. If a larger quantity is needed, 1 fluid ounce of nicotine sulphate, 8 gallons of water, and ½ pound of soap are used. Directions are furnished on the covers of packages, and frequently instructions accompany them.

The spinach aphis (fig. 16), also called "green fly," is more usually pale green, but occasionally pinkish, and is considerably smaller than the potato aphis. During the last decade of the nineteenth century it was extremely destructive to spinach in the tidewater Virginia region. It is what is termed "a general feeder" and is not in any way restricted to tomato and potato, but in recent years, beginning about 1917, it has caused more damage to those crops than to others. It is about equally well known as a pest on cabbage, beets, turnip, radish, celery, parsley, and lettuce, and is also of great importance as an enemy to ornamental plants, including those grown in greenhouses, and to fruit trees.

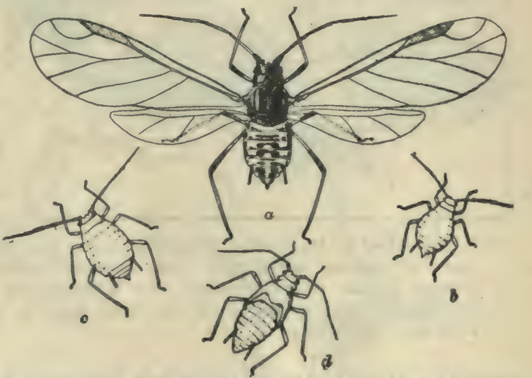

FIG. 16.—Spinach aphis, showing full-grown and young ones. Greatly enlarged.

For the control of this pest about ⅜ pint of nicotine sulphate, 40 per cent solution, should be substituted in the formula given for the potato aphis.

LATE-BLIGHT AND ROT.

Late-blight is the most destructive potato disease. Originating in South America, it has spread to every potato country in the world and has destroyed crops to the extent of causing famine, as in Ireland in 1845.

In the United States late-blight is most common in the Northeastern States, as indicated on the map, Figure 17. In the shaded areas in bad years 50 per cent of the crop in unsprayed fields may be destroyed. It occurs every year in northern New England, and usually visits New York and parts of the adjacent States; in wet seasons it extends as far west as Iowa and Minnesota. It occurs to some extent in the South Atlantic trucking sections from April to June and in the southern mountain region in autumn. The moist, cool climate of portions of the Pacific coast favors its development; but it is seldom or never found on the Great Plains, the Rocky Mountains, and other dry or hot parts of the country.

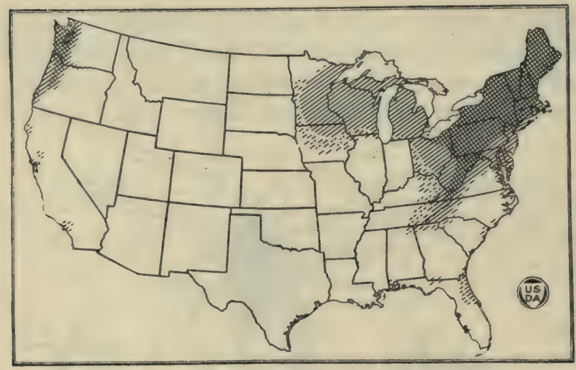

FIG. 17.—Map of the United States, showing the distribution of potato late-blight. The sections where the disease is the most prevalent are indicated by cross hatching. (Map prepared by the Plant Disease Survey, February 14, 1923.)

APPEARANCE OF LATE-BLIGHT AND ROT.

Late-blight develops after the blossom period and does its greatest damage toward the end of the growing season. It appears as purplish black or brownish black spots on the leaves, which, if examined when moist with dew or rain, show a delicate, powdery bloom on the underside. (See fig. 18.) The stems are attacked later, and the entire plant may be destroyed in a few days. If weather conditions favor the disease, fields go down within a few days as if swept by fire, and a foul odor characteristic of the disease is very perceptible.

The blighting of the foliage is followed by decay of the tubers, owing to spores of the blight fungus washed down through the soil from the foliage. If the soil is wet and heavy, there may be a rapid soft-rot caused principally by bacteria. The typical late-blight tuber injury, however, is a dry rot which develops in the field or after storage, as sunken brown spots near the outside of the tuber (fig. 19).

CAUSE OF LATE-BLIGHT.

Late-blight is due to a fungus[14] which lives as a parasite on the potato plant and some of its relatives.[15] This fungus is itself a plant formed of slender moldlike filaments (mycelium) which penetrate the potato plant and feed upon it and later produce vast numbers of minute spores or fruiting bodies. These are spread by wind and water to other plants, which may become infected and produce another crop of spores within five or six days. The tubers become infected by spores washed down through the soil from the blighted foliage or by contact with blighted tops when digging is being done.

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[14] *Phytophthora infestans* (Mont.) DeBary.

[15] The potato late-blight fungus occasionally attacks the tomato, but most of the tomato late-blight is due to a specialized strain of the fungus.

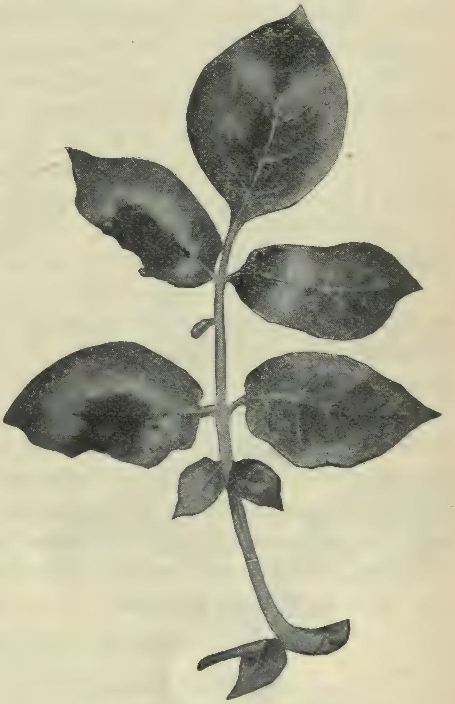

FIG. 18.—Potato late-blight.

FACTORS INFLUENCING LATE-BLIGHT.

The origin of the infection.—Late-blight does not occur in the soil. It overwinters in stored tubers. Potatoes with more or less dry rot are frequently planted, and some of them give rise to weak sprouts. The fungus grows up these shoots and produces spores on the above ground parts, which are carried to adjacent plants and start centers of infection. Such first cases of late-blight often are present in the fields two weeks or more before the disease becomes epidemic.

In preparing potatoes for planting it is important to reject seed potatoes affected with late-blight dry rot, as infected tubers often decay in the ground without germinating, but there is little hope of avoiding the disease by this precaution, since under favorable weather conditions blight is carried many miles in a short time. No method of treating seed potatoes to kill late-blight has been found practicable. Thorough spraying with Bordeaux mixture is the only preventive.

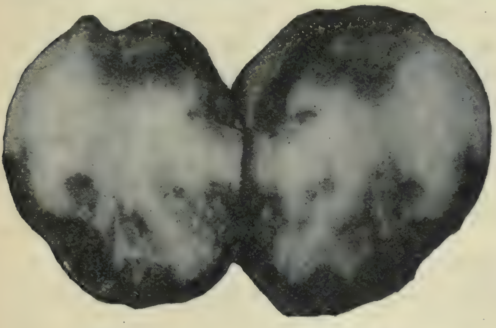

FIG. 19.—Late-blight tuber rot.

Temperature. — Late-blight spreads most rapidly when the daily mean temperature is 72° to 74° F., with abundant moisture. Weather which in the North is designated as "warm and muggy" is therefore favorable to the rapid development of late-blight, whereas the hot summer weather of the Southern and Central States checks it completely.

Moisture.—In dry weather the production of spores is checked, and the disease ceases to spread because the spores can not germinate except in the presence of moisture. Dry foliage can not be infected. It is only when drops of water from rain or heavy dews stand for some hours on the leaves that the disease can gain a foothold. This is an important point to remember in connection with spraying; it explains why all portions of the plant should be covered with Bordeaux and why protection with the spray before rain is needed.

Soil and location.—Hollows or low places in the fields, wherever moisture remains longest, are most likely to develop late-blight, and potatoes on clay soils are likely to suffer more from rot than those on sandy soil.

Varieties.—Partially resistant varieties of potatoes have been bred in Europe, but these are not well adapted to American conditions. We are now developing our own resistant strains, but at present no variety which meets the requirements for a standard commercial sort can be recommended as disease resistant. Select the best variety for your locality and market, and protect from late-blight by spraying with Bordeaux mixture.

PREVENTION OF LATE-BLIGHT TUBER ROT.

1. *Spraying.*—The first essential is to spray, as recommended under the heading "Combined treatment for diseases and insects."

2. *Date of digging.*—It is unwise to dig potatoes when the first blight appears. The immature tubers are not in condition to keep well and they become infected by contact with the tops while being harvested. Consequently, the potatoes should not be dug until a week or more after the tops are entirely dead.

3. *Sorting and storage.*—Immediately after harvesting, sort out all potatoes showing any trace of rot and store the remainder in a dry cellar or storage house, kept cool, as near 36° F. as possible. Dry rot will not develop at this temperature, but in a warm place it will be spread from tuber to tuber.

No treatment with lime, formaldehyde, or other disinfectant is of any value against late-blight dry rot.

OTHER DISEASES.

Several other diseases of potato foliage should be mentioned, to avoid confusion with late-blight. They are listed below in the order of their appearance.

SUNSCALD.

Young potato plants that have made a rapid growth during cool and moist weather may suffer from hot, bright weather. The leaves droop and wilt, and some are killed, but the plants usually recover.

HOPPERBURN AND TIPBURN.

A very prevalent and serious injury to potato foliage, due to the attack of the potato leafhopper, is manifested by a browning of the leaf margins, which become dead and dry, as illustrated in Figure 20. The greater part of the disease hitherto called tipburn, especially in the Central States, is now known to be hopperburn.

A tipburn due to protracted hot and dry weather, complicated by flea-beetle injury and early-blight, occurs as a minor trouble independent of leafhopper injury.

The best protection against both hopperburn and tipburn is thorough spraying with Bordeaux mixture.

EARLY-BLIGHT.

Early-blight is a fungous disease which appears in the North before the late-blight. In the South, however, it is more common on the fall crop. It is likely to occur in all sections of the country.

This disease is marked by the appearance of nearly black spots on the otherwise green leaves. As these enlarge they are marked by faint concentric rings. (See fig. 21.) Eventually the leaves yellow and die, and in cases of severe attacks the tuber yield may be reduced 10 to 25 per cent.

Early-blight attacks weakened plants and is worst upon light soils, not well adapted, by fertility and moisture supply, to potato growing. When conditions favor, it becomes widespread.

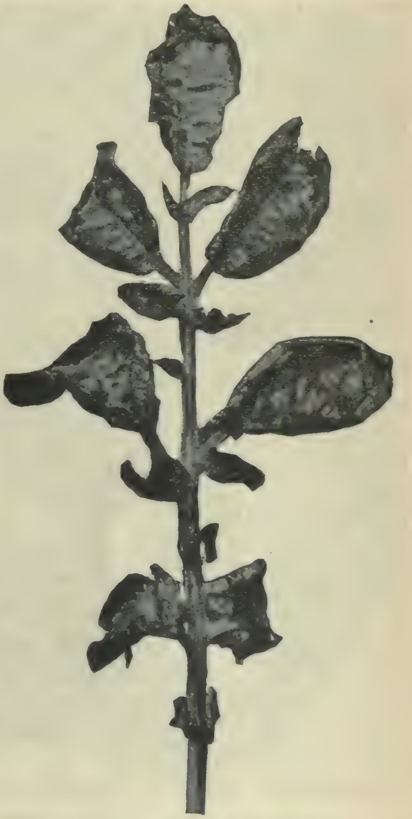
FIG. 20.—Potato hopperburn.

The combined treatment advised below includes Bordeaux mixture for early-blight.

ARSENICAL POISONING.

The use of large quantities of Paris green in water for insect control results in a burning of the leaves, often in concentric spots centering at flea-beetle punctures, somewhat resembling early-blight. When the arsenical is combined with Bordeaux mixture this injury is avoided.

COMBINED TREATMENT FOR DISEASES AND INSECTS.

Watch the young plants closely and spray with Bordeaux mixture and arsenate of lead as soon as the first evidence of the Colorado potato beetle or of flea-beetles is noted.

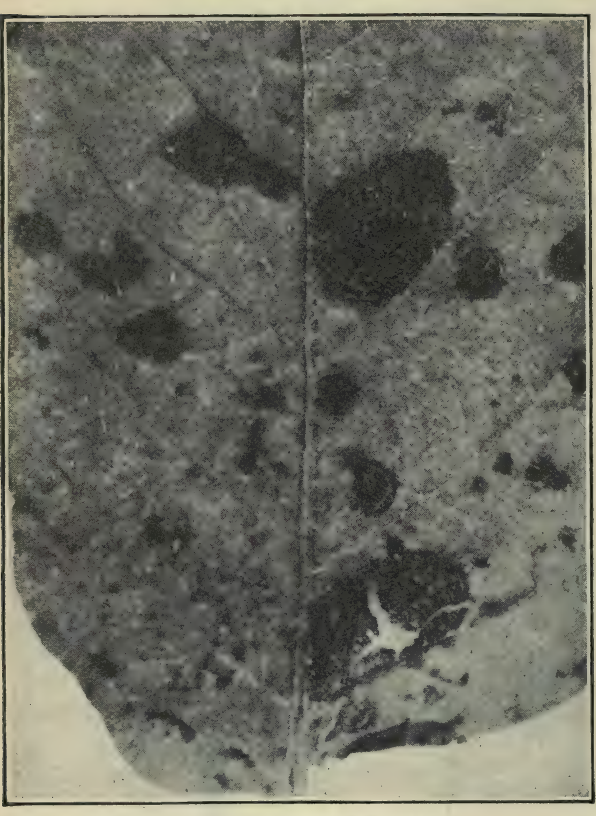

FIG. 21.—Potato early-blight.

Repeat this application every 10 to 14 days to keep all of the new foliage protected. If no insects are present and the weather is dry, the intervals between sprayings may be lengthened.

As the late-blight season approaches, which in the North usually is after the middle of July, a protective spraying should be given and the weather watched more closely, for if continuous showers occur, with a mean temperature of 72° to 74° F., spraying every five to seven days will be necessary.

A system for reporting the appearance and progress of late-blight should be organized in order that potato growers may be warned when to increase their efforts.

VALUE OF SPRAYING.

Throughout most of the late-blight area shaded on the map (fig. 17) it pays to spray potatoes with Bordeaux and arsenicals, whether blight develops or not. With few exceptions, large gains in yield are due to protection from Colorado beetles, flea-beetles, grasshoppers, early-blight, tipburn, etc. This fact has been established by extensive experiments which have been conducted in New York and Vermont. During a 10-year period, at different experiment stations in New York State, an average gain of 60 bushels per acre was secured. At the Vermont station, during a 20-year period, which involved all possible seasonal variations, an average gain of 105 bushels per acre, or 64 per cent over the unsprayed, resulted.

In addition, records taken from a business point of view on a series of experiments of a 9-year duration conducted by farmers under the direction of the New York State Experiment Station show large gains. The average cost of spraying, including materials, labor, and wear and tear on machinery, was $4.74 per acre. The 9-year average increase in yield due to spraying was 36 bushels per acre, making a net profit of $14.43 per acre. When these experiments were conducted the cost of materials was less than at the time this bulletin was written, but the increased product warrants an increased expenditure.

The value of such application of spray annually in regions not included in the blight area (fig. 17) is not so well established. Conditions in the Atlantic coastal region from New Jersey to Florida, for instance, are so different from those farther north that spraying can not be expected to give as large returns as in Maine or New York. In Florida there have been several years when late-blight has prevailed and spraying has been profitable. Here the argument for crop insurance is stronger and spray applications may be advised in number proportioned to the frequency of rain, but always thorough. In New Jersey also, as conditions begin to approach those of the North, gains from spraying may be expected. This is equally true in other regions of the United States, where blight occurs only in occasional years.

The foregoing figures show, however, that spraying is very profitable in districts where potato insects and leaf diseases annually take a big toll. The most successful growers in these districts, who wish to be insured against loss, practice thorough and consistent spraying, knowing that there will be large returns on their investment.

SPRAYING APPLIANCES.

For home gardens small hand sprayers of varying cost and efficiency are to be had.

For the farm potato patch, where from one-half acre to 3 acres are grown and where orchard trees or small fruits are to be sprayed, a barrel spray pump of good capacity is recommended. This hand pump is mounted on a 50-gallon barrel and carried on a homemade two-wheel cart or in a farm wagon.

If a cart is used the nozzle may be fastened to the back to spray four rows, but to do good work with this it is necessary, as with the lighter traction sprayers, to go over the field twice, the second time in the opposite direction.

More thorough work can be done by hand spraying if the pump is fitted with one or two lines of ½-inch hose, 25 feet long, ending in a 4-foot gas-pipe extension. This requires a man for each line and one to pump.

All commercial growers should provide themselves with the most effective traction sprayer they can secure. In these the pump is operated by a chain or gear drive from the wheels. It pays to get the best, as a high pressure of 120 to 150 pounds is needed for effective work. (See fig. 22.)

Gasoline engine power outfits do still better work and are suitable for large growers who desire a sprayer covering four or more rows with three nozzles per row and maintaining at least 200 pounds pressure.

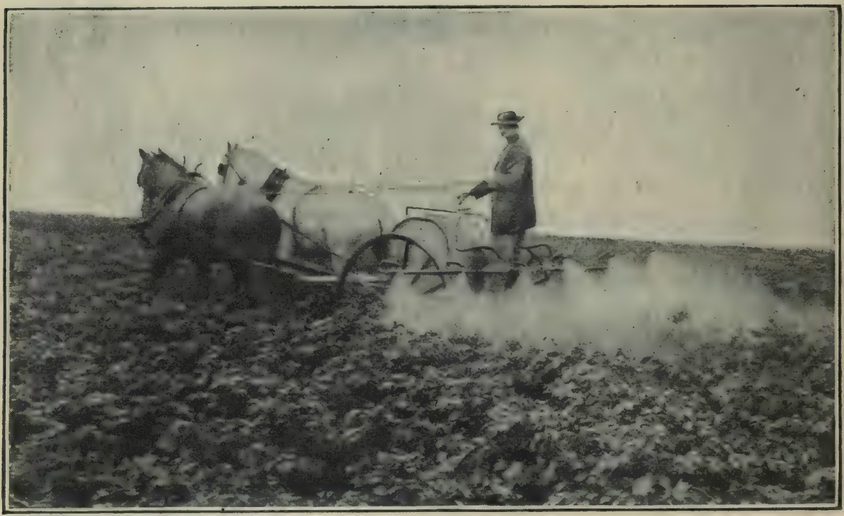

FIG. 22.—Horse-driven power sprayer in use in a potato field.

A good nozzle is one of the most important parts of a spray outfit. The cyclone or eddy chamber type, of which the Vermorel is an example, is the best. The spray produced should be in the form of a fine mist covering every part of the plant.

For small vegetable gardens the common compressed-air sprayer employing a tank holding 3 or 4 gallons and provided with a pump for developing the air pressure is the most effective type. A cut-off in the spray rod retains the liquid in the tank until the desired pressure, as high as can be conveniently pumped, has been obtained. Then the liquid may be released as required. Such a machine costs $6 to $7 in galvanized iron, or $9 to $11 in brass. The latter is preferable, as it lasts longer and is less liable to corrosion by the chemicals used in spraying. (See fig. 23.)

HOW TO PREPARE BORDEAUX MIXTURE.

Bordeaux mixture is the fungicide that has greatest practical value against potato diseases. Lime-sulphur, powdered sulphur, copper lime dust, and other new mixtures that have come into use in orchards are injurious to the foliage, or weaker in fungicidal action, or both. The experiments to date show that for potatoes and other truck crops nothing has yet been found to replace the copper fungicides. The ingredients and method of preparation are as follows:

Copper sulphate	pounds	4
Quicklime	do	4
Water to make	gallons	50

Prepare the copper sulphate by suspending it in a gunny sack just below the surface of several gallons of water in a clean barrel. When the sulphate is dissolved, which requires three or four hours, remove the sack and stir into the barrel enough additional water to make exactly 25 gallons of the copper solution.

Prepare the lime by slaking it slowly and thoroughly in a clean barrel, strain, and add enough additional water to make exactly 25 gallons of lime milk. Stir thoroughly.

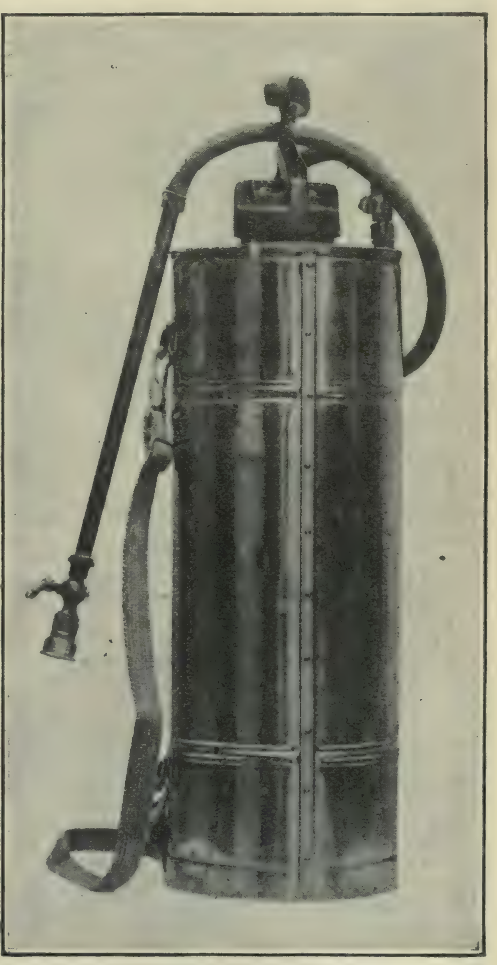

FIG. 23.—Compressed-air sprayer standing upright, showing hose, nozzle, and other attachments.

Pour the two ingredients together into another barrel or, better, directly into the spray tank, if it will hold 50 gallons. It is highly important to stir the mixture very thoroughly and to strain both ingredients before they are combined, as otherwise clogging of the spray nozzles might result. Use copper or bronze wire strainer of 18 meshes to the inch. Do not put copper sulphate or Bordeaux mixture into tin or iron vessels; use wood or copper containers. Mix the Bordeaux solution as needed and apply at once. It is never so good after it has settled.

STOCK SOLUTIONS.

Everyone who uses Bordeaux mixture frequently and in quantity will find it convenient to keep on hand concentrated stock solutions of copper sulphate and of lime in separate containers. These stock solutions keep indefinitely if the water which evaporates is replaced.

Build an elevated platform to hold the barrels. Some time before the day on which you wish to commence spraying, suspend 50 pounds of copper sulphate to dissolve in a 50-gallon barrel of water. Slake 50 pounds of lime in another barrel. Add water to make 50 gallons of lime milk. When Bordeaux mixture is needed, stir both stock barrels and take from each as many gallons as the formula calls for in pounds. Dilute the copper sulphate in one barrel and the lime milk in another, each with half the water, and let the two run together into the strainer of the spray tank. Add the arsenate of lead or other poison and stir well. Thorough agitation is important in making a good Bordeaux mixture.

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U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No 1350

BEEF-CATTLE BARNS

THE ECONOMICAL PRODUCTION of beef cattle in most sections of the United States depends largely upon the investment in durable, convenient, and practical buildings, as well as upon the care, feeding, and management of the herd.

Barns suitable for the successful growing and fattening of beef cattle need not be elaborate nor overexpensive. Any unnecessary outlay of money invested in them adds to the overhead expense.

Appearance, however, should not be neglected, since well-proportioned and well-designed barns may be constructed at very little, if any, additional expense. Such barns add materially to the sale value of a farm property.

Washington, D. C. Issued September, 1923

BEEF-CATTLE BARNS.

By E. W. SHEETS, *Senior Animal Husbandman, Animal Husbandry Division, Bureau of Animal Industry*, and M. A. R. KELLEY, *Barn Architect, Division of Agricultural Engineering, Bureau of Public Roads.*

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TYPE OF BARN.

NO ONE TYPE of barn can be recommended for all conditions because of the many factors to be considered, such as climatic conditions, number and kind of cattle kept, method of handling the herd, availability of material and labor, and individual preferences with regard to details. The choice of type should be influenced by the intended use, whether for fattening cattle, a breeding herd, or for the growing and finishing of cattle. Those just entering into the industry are often confronted with the question whether to build a small temporary shelter providing for immediate needs or one that is substantial, permanent, capable of expansion, and so arranged that it will meet future as well as present needs.

LOCATION OF THE BARN.

The selection of a proper site for the barn is very important and often difficult.[1] Too frequently the matter is given little or no consideration, which generally results in an arrangement that is inconvenient for handling the stock and possibly detrimental to their welfare. After the building is erected and found to be poorly located it is usually impracticable to change its location, except at excessive cost.

The most desirable location is one that will facilitate the movement of stock to and from all fields with the least inconvenience. The barn should be located near the other buildings and in such relation as not to detract from or obscure the attractiveness of the home. Southern slopes underlaid with gravel or sandy subsoil permitting natural drainage are recommended. If the location is level and the ground low or damp it should be well drained before attempting to build on it. Open sheds and feeding lots having a southern exposure will protect the stock from winter winds and storms. The location should be such that the prevailing winds will carry objectionable barnyard odors away from the house.

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[1] In this connection Farmers' Bulletin No. 1132, Planning the Farmstead, will be found helpful. It may be secured free from the United States Department of Agriculture.

It is also important that the barn be placed where sufficient space is available for its possible expansion or for the erection and use of additional buildings, and for lots in which to feed and care for cattle at certain seasons. Provision for the storage of feed, removal of manure, and accessibility to water supply should be carefully planned.

SIZE OF THE BARN.

The size of the barn depends largely upon the number and kind of cattle to be kept, the size of the farm, the type of farming to be followed, the climatic conditions, and the amount of space required for the storage of crops.

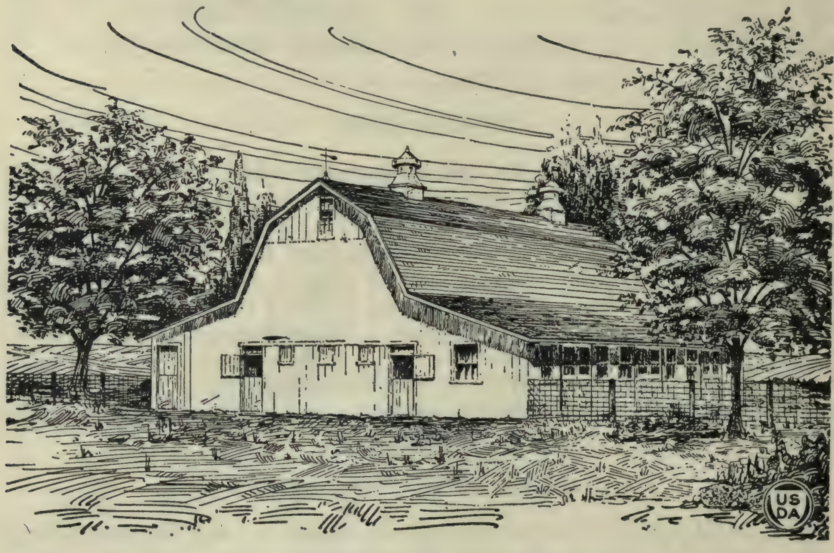

FIG. 1.—General-purpose barn, design No. 612.

It is desirable that the barn be of a size that will meet the existing conditions, but so built as to permit the erection of additions without disturbing the convenient arrangement of or the tearing down of any part of the structure. Sufficient space should be provided for the storage of hay or other roughages to last the entire feeding period. This will eliminate loss of time, labor, and an appreciable amount of the most valuable part of the roughage due to handling in transfer.

The feeding space should accommodate all animals to be fed, so that there will be no crowding. If space sufficient for each animal to stand at the feed trough is not provided, the cow, steer, or calf with a nervous temperament or less voracious appetite may not attempt to eat until the others have finished, and as a result will not do so well. A 30-inch space per animal is usually allowed at the feed trough for fattening steers. They should also have sufficient room to lie down comfortably after eating, to make most efficient use of the feed consumed.

ARRANGEMENT IS IMPORTANT.

The general arrangement of the barn, unless carefully planned, may cause many unnecessary steps and greatly increase the labor in feeding and caring for the cattle. Among the more important points to be considered are the locations of the silo, water tanks, feed room or bins, hay chutes, driveways, feed alleys, stalls, doors, and windows.

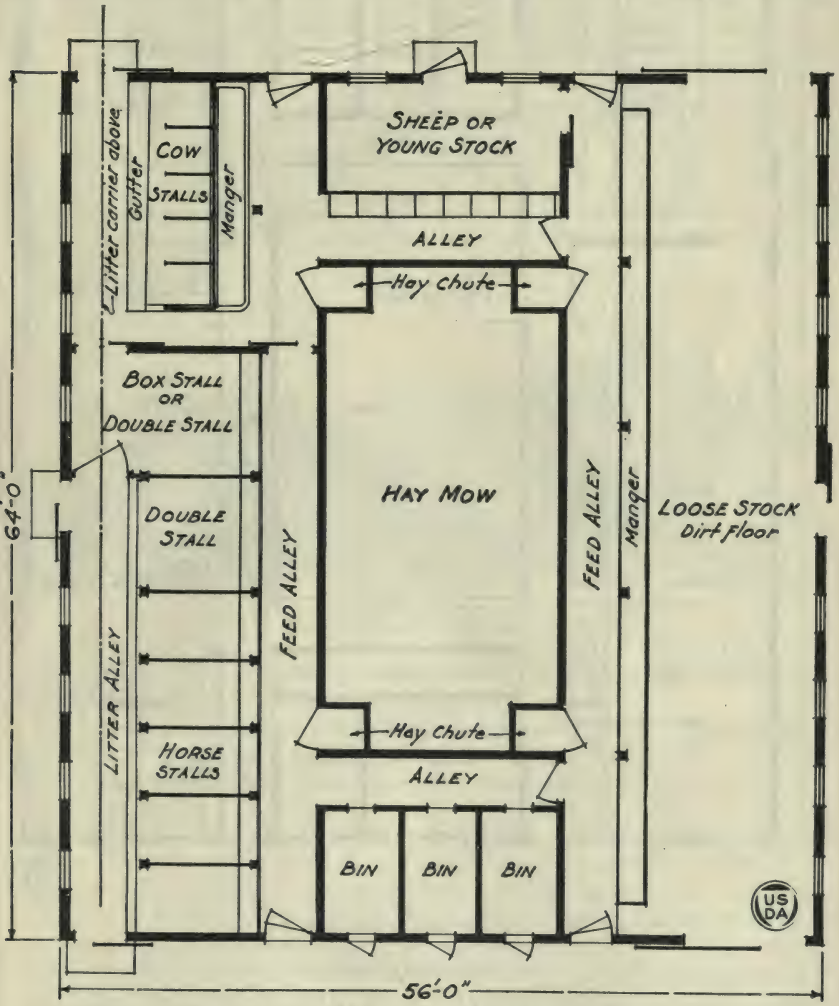

Fig. 2.—Alternate floor plan for design No. 612.

Hayracks and feed troughs should be arranged so as to permit the feeding of the cattle with the least labor. The use of feed carriers, carts, wagons, or other labor-saving equipment is desirable and the barn should be planned to provide for these features. Time and labor may be saved in removing manure if the barn and lots are made easily accessible for a wagon or manure spreader.

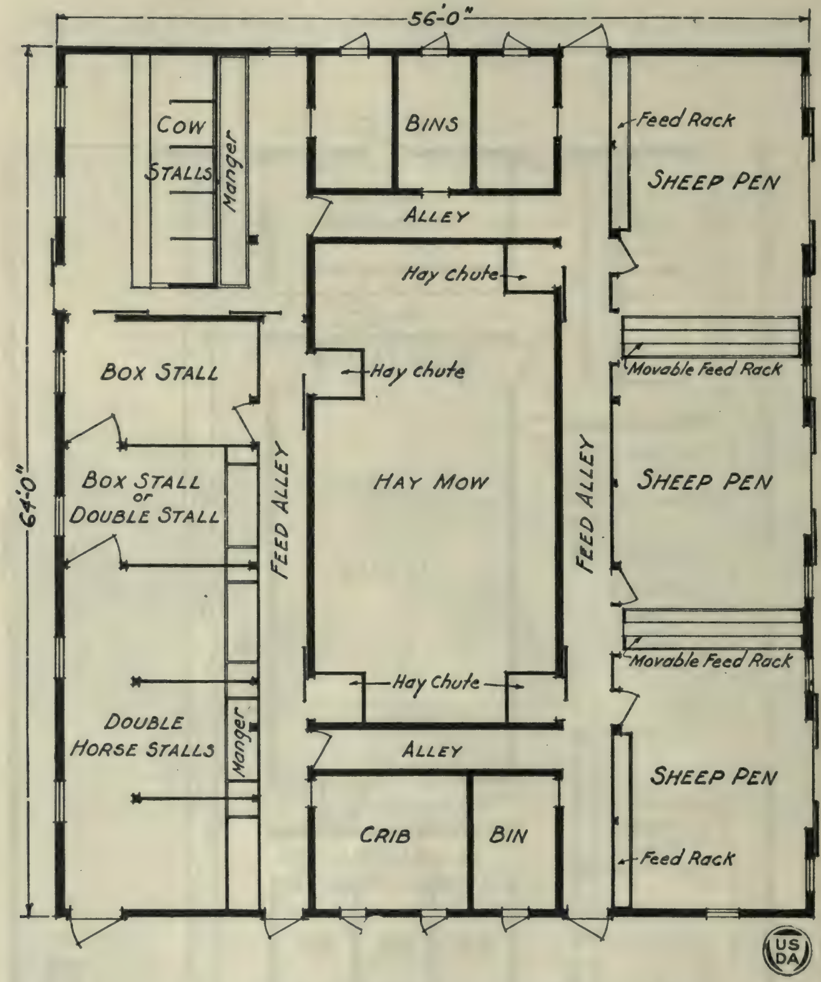

Fig. 3.—Floor plan of design No. 612.

THE FEED LOT.

The location of the feed lot or lots with relation to the barn, fields, and lanes has a decided bearing on the ease with which the stock may be handled. The arrangement of the lots will depend on the surrounding conditions, which vary widely because of different methods of handling. Lots should be capable of being well drained, either naturally or with tile; muddy lots are responsible for losses in manure, also for losses of feed in the droppings which hogs following the cattle make use of. In addition to this, cattle fed in a dry or paved lot have a better appearance, which is attractive to buyers.

The loss in market value of the stock, added to that of manure and grain, when hogs follow the cattle, may amount to enough to pay in a few years' time for the construction necessary to prevent the waste.

A concrete pavement,[2] with rough surface, laid over a good layer of broken stone or gravel and covered with a reasonable amount of bedding, is the most desirable means of avoiding a muddy feed lot. The pavement may be of brick or cobblestone laid on a gravel bed and flushed with a cement grout. The edges of any such paving should be protected by a wall which will prevent undermining and raveling. Broken stone covered with gravel makes a fairly good surface, especially if underdrained with tile. The paving should be sloped to gutters that will lead the liquid manure to a water-tight tank, or pit, from which it may be taken and applied to the land. Surface water from an adjacent slope may be kept out of the lot by ditching. Roof water should be led through drains to a point outside of the lot.

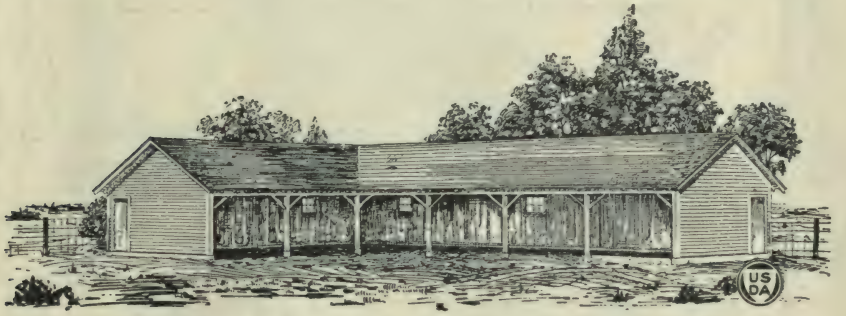

FIG. 4.—Design No. 763, open shed for shelter.

Board or plank fences are the most satisfactory for inclosing small lots adjoining barns and sheds. Woven-wire fences are comparatively short-lived when used to confine stock in small inclosures. The strain put upon a woven-wire fence by cattle rubbing, fighting, or reaching over will sooner or later break the wires or reduce the tension so that the fence will cease to serve its purpose efficiently.

A board fence 5 to 6 feet high constructed of from 5 to 7 horizontal 2 by 6 inch planks, of a durable wood, 16 feet long, nailed preferably to strong posts set 8 feet apart, is quite satisfactory. While the life of the posts may not be materially increased by setting them in concrete, yet the greater stability and better anchorage will usually warrant this construction. It is especially desirable that corner and gate posts be so set. The concrete should extend 8 to 12 inches above the ground and the butts of the posts should be treated with a preservative.[3] The feed-lot gates should be arranged so as to be convenient for handling the cattle and removing the manure.

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[2] Directions for the construction of such floors will be found in Farmers' Bulletin No. 481, Use of Concrete on the Live-Stock Farm, which may be had free on request to the United States Department of Agriculture, Washington, D. C.

[3] See Farmers' Bulletin No. 744, The Preservative Treatment of Farm Timbers.

BARN VENTILATION.

The importance of proper ventilation in dairy barns is now generally recognized by successful dairymen, but ample ventilation in beef-cattle barns is not so widely appreciated. This probably is due to the fact that it is not thought necessary to provide such warm structures for beef cattle as for dairy cows, and since more open structures are used, there is more or less leakage of air through the barn walls.

It is impracticable to make barns air-tight, and uneconomical to make the walls highly efficient as nonconductors of heat. In the northern parts of the country, where it is necessary to provide warm structures for stock, the importance of ventilation increases in proportion to the tightness of the building. In order that the ventilation may be made most effective and the least amount of heat be carried off, it is necessary to direct the currents of air entering and leaving the barn into proper channels, so that the amount of circulation may be properly controlled.

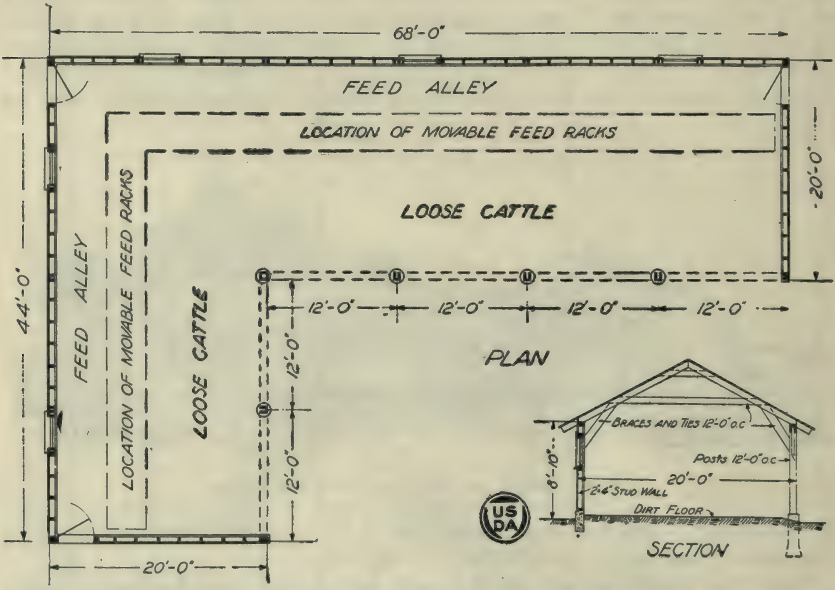


FIG. 5.—Floor plan and section of design No. 763.

There are three elements which are essential to animal life, namely, feed, water, and air, and upon the quantity and quality of all three depends the physical welfare of the animal. It is not necessary to know the least amount of air essential to animal life, any more than it concerns us how little feed is required to maintain life. We expect more than mere existence from our farm animals, and in order that they may be productive they must be well fed and watered and must have an abundance of fresh air. All animals are not affected to the same extent by breathing vitiated air, and often the effects are not noticed until it is too late to correct the condition. Fresh air is the first thing prescribed for patients suffering with tuberculosis. Tuberculosis in livestock is not only a menace to the animals, but it is disastrous as well to human life, and many cases of tuberculosis found among children are of bovine origin.

The greatest safeguard against disease is a well-nourished body; hence it is obvious that an abundant supply of pure air is essential. Breeding animals especially should be kept strong and vigorous. They can not be expected to thrive if compelled to breathe vitiated air in poorly ventilated barns. Recent investigations indicate that a 1,000-pound cow throws into the air approximately 10 pounds of moisture a day. From a herd of 40 cows there would be given off 400 pounds or more than 50 gallons of water per day. This amount of moisture must be removed daily in order to keep the stables sweet and free from dampness. Only by proper ventilation of the barn can this be done.

If moisture is allowed to condense on the walls, the dampness, combined with offensive odors, will make the air in the stables oppressive. Disregarding any effect this condition may have on the health of the livestock, it is still important that the moisture be removed in order to prevent mold and decay of the timbers of the barn.

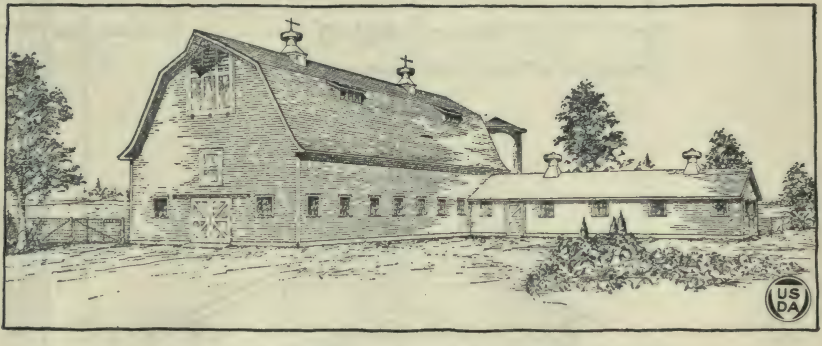


FIG. 6.—Barn for the breeding herd, design No. 1495.

Hay chutes are sometimes used as foul-air shafts. In the colder sections of the country this practice often causes frost to collect on the underside of the roof, and as the temperature rises the underside of the sheathing in the mow becomes damp and water drips on the hay. This frequently renders the hay less nutritious and palatable. The condition is also conducive to rot in the sheathing and roof timbers. The best results are to be obtained by ventilating systems properly installed and all hay chutes closed with either a hinged or sliding door, so as not to interfere with the ventilating system.

It is not within the scope of this bulletin to discuss the principles or details of barn ventilation. It is sufficient to state that the King system, or some modification thereof, is suitable for the barns described in this bulletin. The King system consists essentially of two sets of flues, one used for the removal of impure air and the other for the addition of fresh air.

The flues should be arranged so that all the foul air is taken from near the floor and discharged through ventilators on the roof, the fresh air coming in near the ceiling of the stable. In mild climates

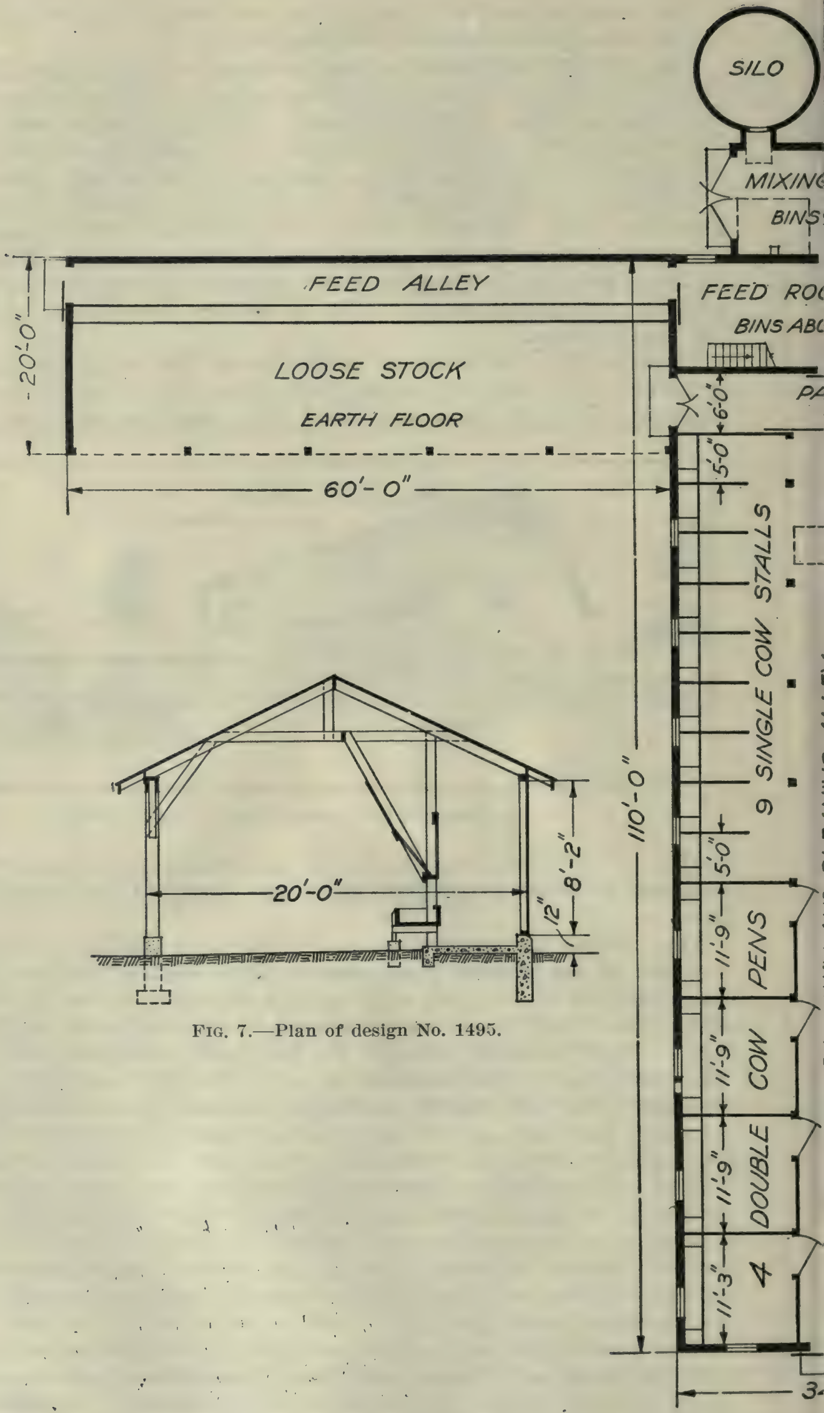
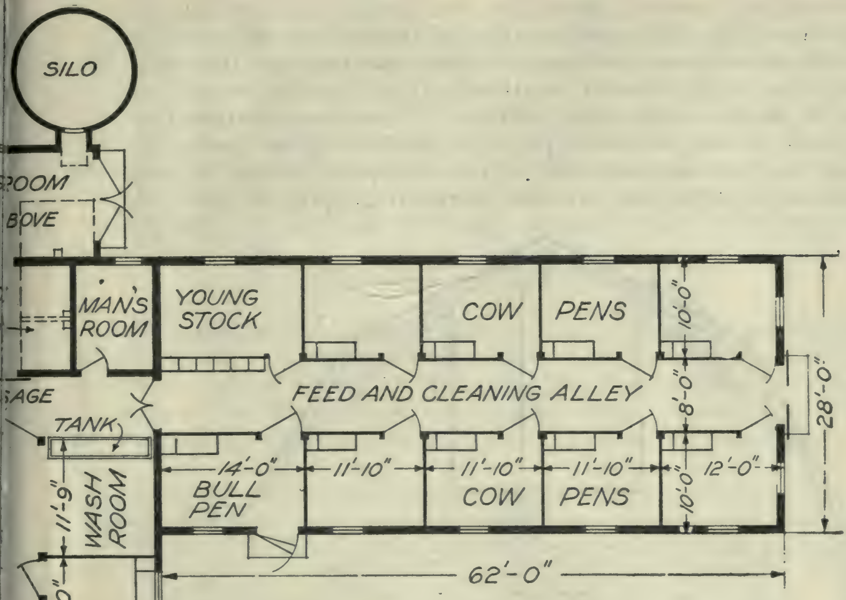
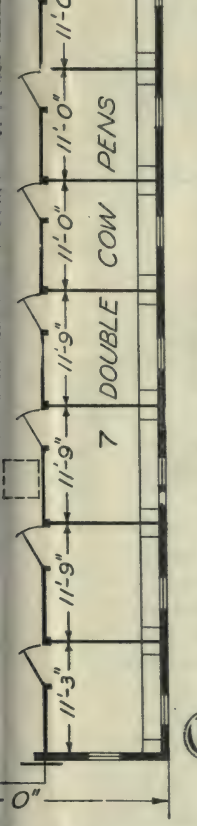


FIG. 7.—Plan of design No. 1495.

FIG. 8.—Section through

ding barn, design No. 1495.

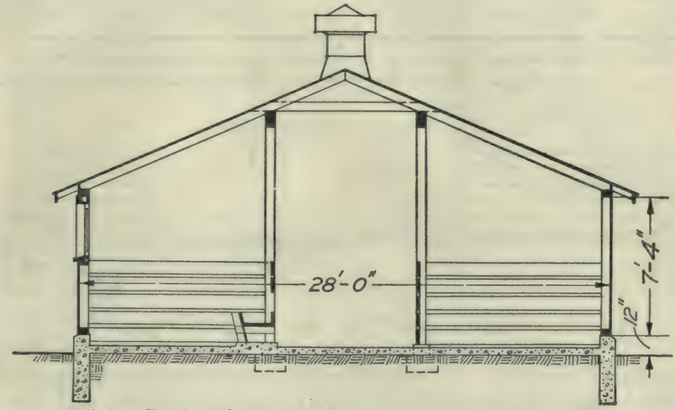


FIG. 9.—Section through maternity shed, design No. 1495.

the air is sometimes removed through a flue or duct the entrance to which is at the ceiling, but in cold sections of the country the opening in the flue should be near the floor. A door opening into the foul-air flue near the ceiling should be provided and should be used in ventilating the barn during warm weather. A cow-barn outtake flue 30 feet or more in height should provide about 30 square inches of cross-section flue area for each cow within the space affected by the flue. From one to three flues are used. depending upon the size and arrangement of the barn. Thus each of three flues in a barn housing 30 head should have an area of 300 square inches.

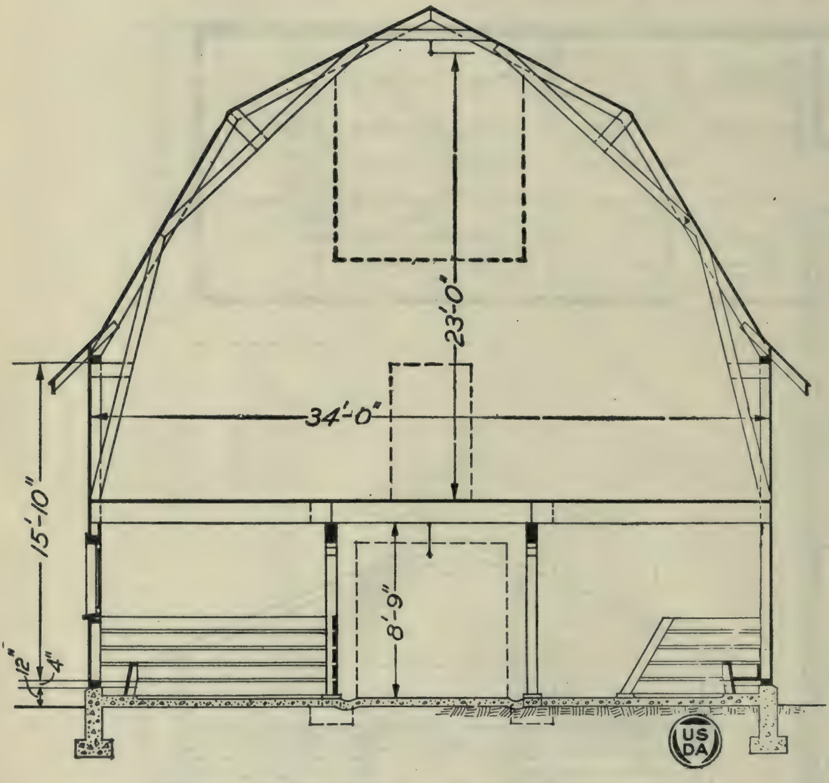


FIG. 10.—Section through main barn, design No. 1495.

The proportionate area of intake flues is usually somewhat less. It depends largely upon the openness of the structure. In mild climates the intake ducts are sometimes omitted and sufficient ventilation obtained by constructing the windows so that they drop in at the top as much as 10 inches. Intake ducts are desirable in the colder sections, as they afford better regulation of the ventilation system. The openings of intake ducts are usually made 6 by 12 or 8 by 14 inches, and the flues should be 5 feet or more in length. They should be located on both sides of the barn and placed 10 to 20 feet apart, so that the incoming air will be distributed fairly uniformly.

In the South, ventilation of barns is comparatively simple. It is only necessary to construct the building so as to secure an abundance of ventilation throughout the year and to afford protection from the north winds in the winter. Obviously, the barns in this section may be of cheaper construction. Ventilation of the more tightly built barns of the North should be carefully considered. In designing the ventilation system for any barn, it is necessary to study the arrangement of the floor plan and also take into consideration the local conditions.

CONSTRUCTION OF THE BARN.

A full discussion of all the details of barn construction within the limits of this bulletin is not feasible. The plans illustrated in the following pages have been prepared for the purpose of assisting farmers in erecting suitable structures. They are intended to meet, in a general way, conditions found in most representative beef-producing sections and are suggested rather than definite solutions of the barn problem. They may be modified with respect to dimensions, arrangements, and details of construction. Complete working drawings and bills of material for the barns shown herein may be had by those who contemplate building upon application to the Division of Agricultural Engineering, Bureau of Public Roads, United States Department of Agriculture, Washington, D. C. In requesting plans, reference should be made to the design number. The plans showing alternate arrangements are intended to suggest modifications which may be made in the original designs and which may better meet the requirements in some instances. Complete working drawings of the alternate schemes are not available.

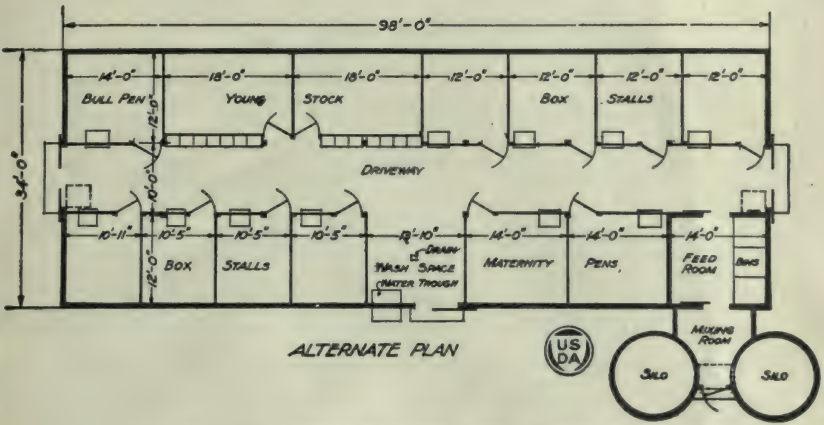


FIG. 11.—Alternate floor plan, design No. 1495.

BARN DESIGNS.

GENERAL-PURPOSE BARN.

General-purpose barns provide shelter for the stock carried on many farms of moderate size, together with sufficient space for storage of feed. The concentration of the stock in one structure saves time in caring for them. Design No. 612 (Fig. 1) provides, in addition to cow and horse stalls, pens for about 65 sheep (see Fig. 2). An alternate plan (Fig. 3) is arranged for handling about one carload of loose beef cattle. The barn, arranged as in the alternate plan, is suitable for diversified farming where conditions make some shelter for the beef cattle desirable and where this part of the farm business is not of sufficient importance to warrant separate buildings. The capacity of the mow is approximately 58 tons, of the bins 300 bushels each, and of the crib 300 bushels of ear corn. As the hay rests on the ground in the center of the building, a mow floor of heavy construction is not required. The low mow reduces the height to which hay must be hoisted with the hayfork or sling and saves several feet of climbing when hay is to be thrown down for feeding. This barn is very popular in sections where home-sawed lumber is available.

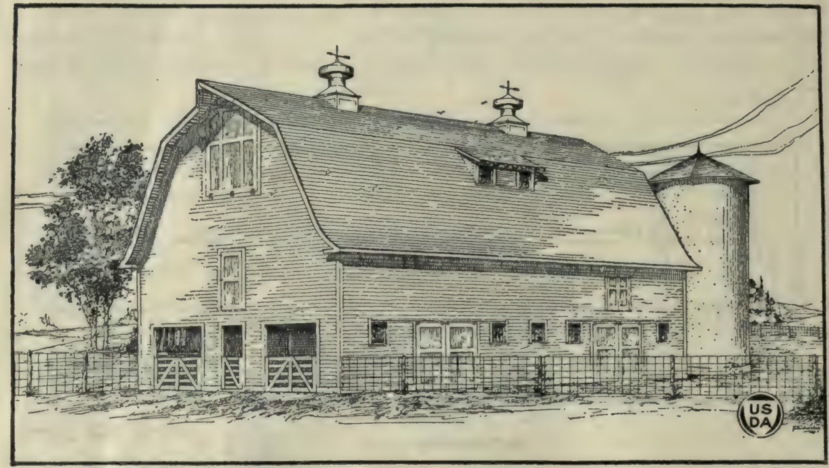


FIG. 12.—Design No. 1175, cattle-feeding barn (closed type), suitable for northern conditions.

CATTLE-FEEDING BARNS.

While cattle-feeding barns are not a necessary equipment in the fattening of cattle, yet many feeders prefer to do all their feeding under shelter. This practice is quite common in Indiana, Illinois, Wisconsin, Minnesota, and the Dakotas. Under this system all the roughage needed for the feeding period, and a considerable part of the grain and concentrates, are stored in the barn. This favors a saving of labor and time in feeding and also a saving of feed. Feed stored in the open is seriously affected by the weather. The closer the feed is stored to the feed troughs the less will be the loss of feed in handling. Feed should always be stored under cover, and with this in view it is well to consider the advisability of building a barn or feeding shed having capacity not only for the feed but for the feeding operation as well. Unquestionably feeding barns have a greater use in the colder climate where winter storms are more severe.

Designs Nos. 1175 and 1185 (Figs. 12 and 14) are of the same general construction, except that the former is of the closed type and more suitable for feeding in localities where the climate is severe. In milder climates such as are found in the Central and Southern States the open type is equally as satisfactory.

The closed type of feeding barn is suitable for fattening about two carloads of cattle. Stock can enter and leave the barn freely, and by the use of sliding doors they may be given ample protection during stormy weather. The feeding is done from a central alley, using a silage truck or overhead feed carrier running from the silos through the feed room (Fig. 13). In the shed connecting the silos with the barn provision is made for the storage of concentrates and mill feeds. An outside door between the silos makes it feasible to haul silage by wagon to troughs in the open lot. The number and size of silos depend upon the quantity of silage to be fed and the length of the feeding period. Hay mangers and chutes are arranged along the outside walls. In this position the chutes occupy less valuable mow space and do not interfere with mowing away the hay. The mow has a capacity of about 100 tons of loose hay.

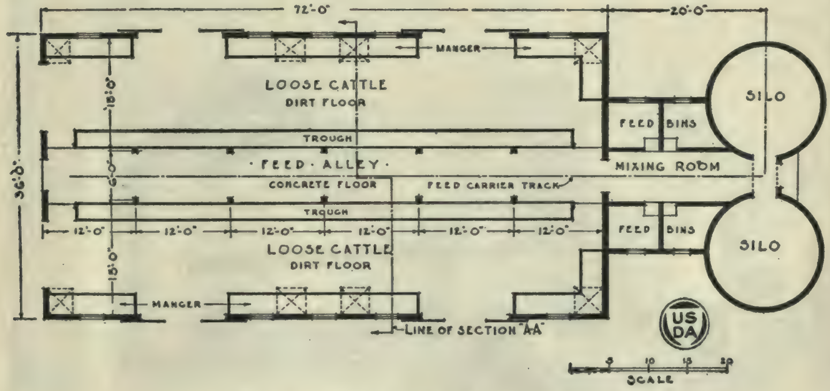


FIG. 13.—Floor plan of design No. 1175.

Hay mangers of the type shown permit the use of windows in the side walls, making the interior lighter and affording better ventilation. However, there is the disadvantage that when windows are used with racks such as shown in Figures 13 and 16, part of the light is cut off and the glass is frequently broken.

The small doors over the large side openings are for convenience in throwing out hay or bedding for use outside of the barn. The dormer windows in the roof add a little to the expense, but offer an appreciable advantage which is often overlooked, as they provide light in the center of the mow. As most of the cattle feeding is done during the winter months, when the days are short, the extra light is very desirable. The dormers also add to the appearance of the barn, and during the haying season, if opened, make the mow a much more comfortable place for work.

The arrangement of barn in design No. 1185 (Fig. 15) is practically the same as that of design No. 1175 (Fig. 13), except that the sides are left open, as it is intended for use in mild climates. The framing of the barn is designed for the use of vertical boarding. The same framing may be used in design No. 1175, but vertical boarding is less desirable in cold climates, as it does not make so warm a barn.

An alternate plan (Fig. 16) is constructed so as to permit feeding by the use of a team and wagon. Combination hay mangers and feed troughs may be placed along the outside wall of design No. 1175, thus nearly doubling the feeding capacity of the barn. The feed could be shoveled from a wagon to the troughs on each side.

CATTLE SHEDS.

Buildings are important factors in the operating expense of fattening cattle. It is only proper that cattle should be charged for the equipment they use. Interest, depreciation, and upkeep charges on that portion of the equipment used by the cattle should be charged to them. Therefore, unusually expensive buildings and equipment devoted exclusively to fattening cattle might mean the difference between loss and profit on a bunch of steers.

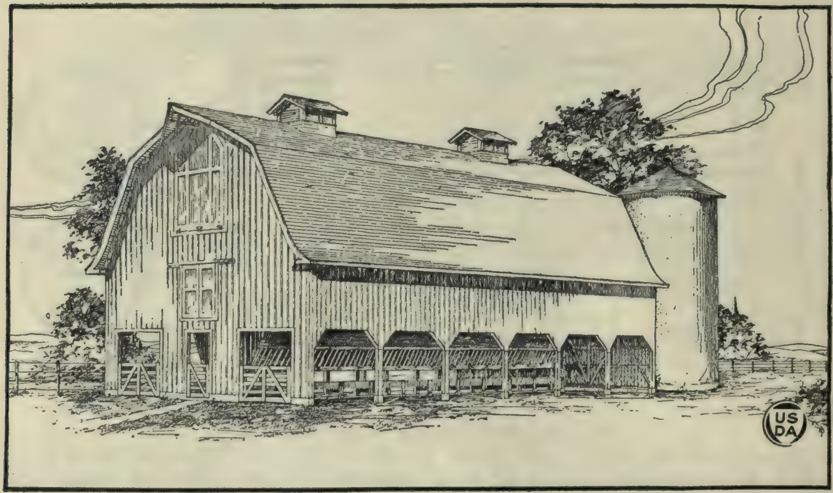


FIG. 14.—Design No. 1185, cattle-feeding barn (open type), suitable for southern conditions.

It is not necessary to have extra good barns for steer feeding alone. In many cattle-feeding sections, a shed having an open side or end is all that is necessary for shelter. If cattle are kept dry and have protection from the winds and storms by having access to a shed they will do very well, other factors being equal. It is advisable to have all feed under cover. A very desirable shed is one having space for hay and straw, for both feed and bedding, in the center or on one side, and permitting the cattle to eat these roughages under cover and have a place to lie down in cold weather.

A cattle shed intended to provide shelter for cattle fed in open lots is shown in design No. 763 (Figs. 4 and 5). The silage, grain, and hay must be stored in other buildings. Feed troughs and racks may, if desired, be placed within the shed as indicated in Figure 5. The shed may be either L-shaped or straight and of any desired length. In some locations the L shape may be preferred, as it forms a better windbreak for the feed lot.

BARN FOR BREEDING HERD.

The average requirements of the breeder of beef cattle are provided for in design No. 1495 (Fig. 6). The main building contains double cow pens, stalls for nurse cows, and a wash room, feed room, and herdsmen's room (Fig. 8), centrally located. Mangers are placed against the outer walls. However, this may be modified as shown in alternate plan, Figure 11.

Two silos are placed at one end and are connected to the main building by a covered driveway with feed bins above. The floor of the driveway is of concrete and is suitable for mixing feed. The feed room on the ground floor is intended for the storage of sacked feed.

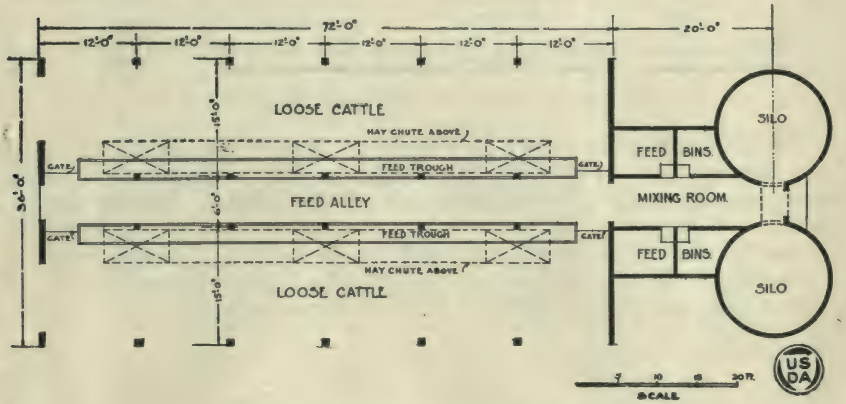


Fig. 15.—Floor plan of design No. 1185.

The mow of this barn has a capacity of approximately 110 tons of hay. Two feed bins with chutes to the lower floor are shown at the end of the mow nearest to the silos. These may easily be omitted if not desired.

Attached to the barn on the left side is a feeding shed for loose stock, and on the right a one-story shed containing a bull pen and calving pens. The T-shaped arrangement of the group affords ample protection from cold winds. The central location of the feed storage and mixing room makes feeding very convenient. Either shed (Figs. 7 and 9) may be made two stories high, with a gambrel roof, if additional space for bedding storage is required. In very cold climates a mow over the right wing, containing box stalls or pens, may be desirable because of the additional warmth it provides.

If overhead feed and litter carriers are employed, it is not necessary to drive through the barn, but it may be made possible by placing the silos farther apart and extending the driveway between them.

Drainage of the main barn and of the right wing is accomplished by means of shallow concrete gutters leading to bell traps. This system requires a minimum amount of under-floor piping. Catch basins should be provided outside the building on each drain line to intercept solid matter likely to cause stoppage in the pipes and to facilitate cleaning the drains.

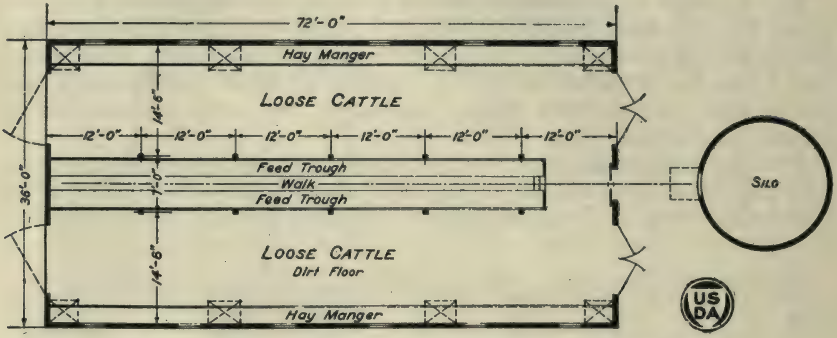


FIG. 16.—Alternate floor plan for designs Nos. 1175 and 1185.

The alternate plan shown in Figure 11 is very similar to the main barn design, No. 1495, with the wings on each side omitted. This barn usually meets the requirements of the smaller breeder or beginner. Wings may be connected to this main barn as the herd increases in size. The silos are placed on one side of the barn, making it possible to have a driveway through the barn sufficiently wide to permit the passage of wagons or manure spreaders.

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